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FINAL
SITE-SPECIFIC TECHNICAL REPORT (A003)

for

SHORT-TERM PILOT TEST FOR THE BIOSLURPING FIELD INITIATIVE AT WRIGHT-PATTERSON AFB, DAYTON, OHIO

by

J.A. Kittel, E. Drescher, L.A. Smith, and M. Place

for

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EXECUTIVE SUMMARY

This report summarizes the field activities conducted at Spill Site 5, Wright-Patterson AFB, Ohio, for a short-term field pilot test that compared vacuum-enhanced free-product recovery (bioslurping) to traditional free-yproduct recovery techniques to remove LNAPL from subsurface soils and aquifers. This test was conducted at a site directly across the street from WPAFB Building 70 (Area B). The field testing at WPAFB is part of the Bioslurping Field Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE). The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficiency of bioslurping technology for (1) recovery of light nonaqueous phase liquid (LNAPL) from groundwater and the capillary fringe and (2) enhancing natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

The main objective of the Bioslurping Field Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at WPAFB is one of at least 35 similar field tests to be conducted at various locations throughout the United States and its possessions.

The intent of field testing is to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping technology for removal of free product and remediation of the contaminated area. The on-site testing is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method included an initial evaluation of site variables followed by LNAPL recovery testing. The specific test objectives, methods, and results for the WPAFB test program are discussed in the following sections. The three technologies used at Wright-Patterson AFB to recover the free LNAPL floating on the water table were skimmer pumping, vacuum-enhanced pumping (bioslurping), and drawdown pumping.

Site characterization activities were conducted to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. Testing included soil sampling, slug testing, in situ respiration testing, and baildown testing.

After the site characterization activities, the actual pilot tests for the skimmer pumping,

bioslurping, and drawdown pumping were conducted. The bioslurper system was installed in an existing extraction well, Well #P6-2. The pilot test sequence was as follows: 1 day in the skimmer mode (no vacuum); 4 days in the bioslurper mode (vacuum-enhanced mode); and 1 day in the drawdown mode (groundwater depression mode). Measurements of the extracted soil gas composition, free product thickness, and groundwater level were taken throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

Each of the three recovery configurations tested was able to recover LNAPL from Well #P6-2. The rates of LNAPL recovery during the first day of each configuration were 4.01 gal/day, 11.3 gal/day, and 2.45 gal/day for skimmer pumping, bioslurping, and drawdown pumping, respectively. As expected, the rate of recovery was highest at the beginning of each test. The LNAPL recovery rates during the skimmer and drawdown pumping configurations declined rapidly and approached 0.0 gal/day by the end of each 1-day test. The LNAPL recovery rate during the 4-day vacuum-enhanced recovery test decreased each day of the test but still was more than 1.5 gal/day even after 4 days of operation. Clearly, LNAPL recovery was significantly enhanced by the application of the bioslurper/vacuum enhanced recovery technology.

In addition to increased LNAPL recovery, the vacuum-enhanced pilot test demonstrated the ability of the bioslurping technology to increase vadose zone oxygen concentrations over the undisturbed oxygen-limited conditions. Operating in the bioslurper configuration increased in situ oxygen concentrations to above oxygen-limited conditions in all monitoring points. In situ respiration testing indicated an average biodegradation rate of 2.0 mg/kg/day, or 730 mg/kg/year.

Implementation of bioslurping at the Wright-Patterson AFB pilot test site likely would facilitate enhanced recovery of LNAPL from the water table and simultaneous in situ biodegradation of hydrocarbons in the vadose zone via low flow vapor extraction (bioventing). Feasibility of implementing bioslurping would depend on long-term requirements for vapor treatment (not required during the short-term test) and disposition requirements for extracted groundwater (1.3 gpm/well).

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SITE-SPECIFIC TECHNICAL REPORT

for

SHORT-TERM PILOT TEST FOR THE BIOSLURPING FIELD INITIATIVE AT WRIGHT-PATTERSON AFB, DAYTON, OHIO

1.0 INTRODUCTION

This report describes activities performed and data collected during a field test of vacuum-enhanced pumping (bioslurping) at Wright-Patterson Air Force Base (WPAFB), Ohio. The field testing at WPAFB is part of the Bioslurping Field Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE). The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficacy of bioslurping technology for (1) recovery of light, nonaqueous phase liquid (LNAPL) from groundwater and the capillary fringe and (2) enhancement of natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

1.1 Objectives

The main objective of the Bioslurping Field Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and to identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at WPAFB is one of at least 35 similar field tests to be conducted at various locations throughout the United States and its possessions. Aspects of the testing program that apply to all sites are described in the *Test Plan and Technical Protocol for Bioslurping* (Battelle, 1995). Test provisions specific to activities at WPAFB are described in a site-specific test plan, which is attached as Appendix G.

The purpose of field testing is to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping technology for removal of free product and remediation of the contaminated area. The on-site testing is structured to allow direct comparison of LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method included an initial evaluation of site variables followed by LNAPL recovery testing. The specific test objectives, methods, and results for

the WPAFB test program are discussed in the following sections. The three technologies used at Wright-Patterson AFB to recover the free LNAPL floating on the water table were skimmer pumping, vacuum-enhanced pumping (bioslurping), and drawdown pumping.

1.2 Testing Approach

Initial site characterization activities were conducted to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. These activities included soil sampling to determine physical/chemical site characteristics, slug tests to evaluate the hydrogeologic conditions near the test well, in situ respiration testing to evaluate site microbial activity, and baildown tests to evaluate the mobility of LNAPL in the site monitoring well.

Following the site characterization activities, the actual pilot tests for the skimmer pumping, bioslurping (vacuum-enhanced pumping), and drawdown pumping were conducted. The bioslurper system was installed so that an existing groundwater extraction well, #P6-2, could be used for the testing. The LNAPL recovery testing was conducted in the following sequence: 1 day in the skimmer mode (no vacuum); 4 days in the bioslurper mode (vacuum-enhanced mode); and 1 day in the drawdown mode (groundwater depression mode). The tests normally would follow immediately in sequence, but the drawdown mode test in the WPAFB testing was performed about one month after the skimmer and bioslurper tests due to problems with the vacuum pump operation and disposition of extracted groundwater. Measurements of the extracted soil gas composition, free product thickness, and groundwater level were made throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

2.0 SITE DESCRIPTION

Figure 1 shows the location and main features of the area used for the pilot testing. Well P6-2 is located directly across C Street opposite WPAFB Building 70 (Area B), which is a fuels-testing facility. Also shown in Figure 1 is the general arrangement of the test site .

Site personnel indicate that underground storage tanks (USTs) located in front of Building 70 are the most likely sources of contamination in the area. This area is labeled as Spill Site 5 in Figure 1. The existing fuel plume that is contaminating the soils and groundwater in this area is JP-4 jet fuel. Previous characterization of the soil-gas vapor have shown that TPH and benzene concentrations in the pilot test area range from 8.0-8.2 mg/l and 0.001-0.002 mg/L, respectively.

At WPAFB, extracted groundwater cannot be discharged directly to the base sanitary sewer system. It must be analyzed for BTEX and TPH contamination before it can be discharged. In order to conduct the pilot tests, an arrangement was made with the base PoC to hold the extracted groundwater until it could be disposed of properly through the base industrial-waste treatment plant. A 10,000-gal holding tank located in WPAFB Area B (OU10) was used to hold groundwater extracted during the short-term pilot testing. Base personnel made all arrangements for disposal of the groundwater. Given the brief duration of the pilot test, the low airflow rate, and the low expected concentration of organics in the off-gas, no point-source air discharge permit was required by the state of Ohio EPA for vapor discharge from the system.

2.1 Site Contaminant Profile

It appears that the fuel contamination at this site is localized in a relatively thin layer at the water table surface. Thus, there is limited overlying vadose zone soil contamination. The free product detected at well #P6-2 is likely the result of lateral migration of the fuel along the water table surface as opposed to a top-down surface spill. The fuel is also highly weathered, which is representative of an older spill site.

2.2 Well Construction Description

Well #P6-2 was selected for use in the bioslurper pilot test. Well construction details are presented in Figure 2. The well is constructed of 2-inch diameter, schedule 40 pvc. Total depth of the well is 29.0 ft, with a screened interval of 17.5 ft to 28.0 ft.

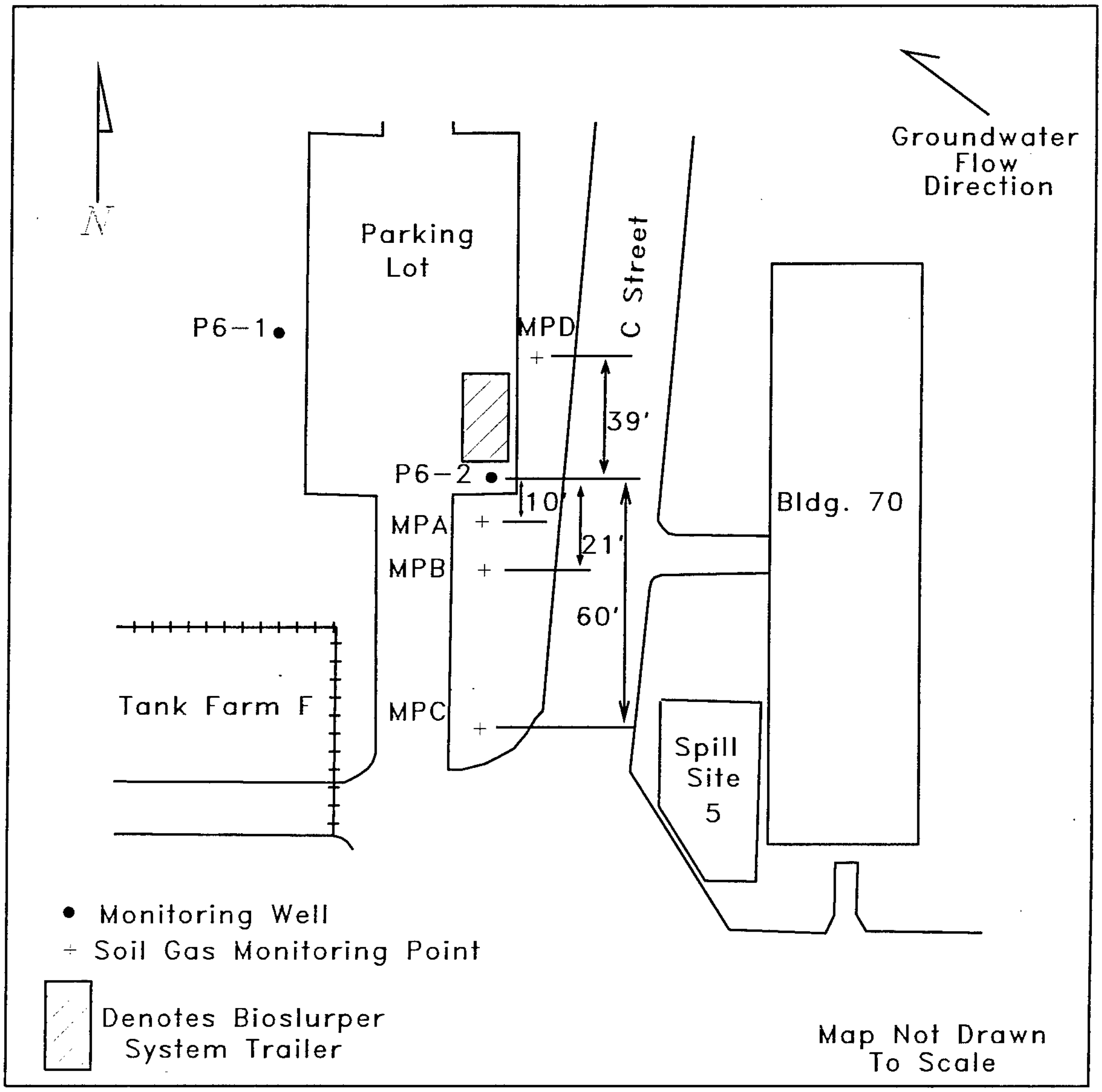


Figure 1. General Arrangement of Bioslurper Monitoring Point and Equipment at the Test Site.

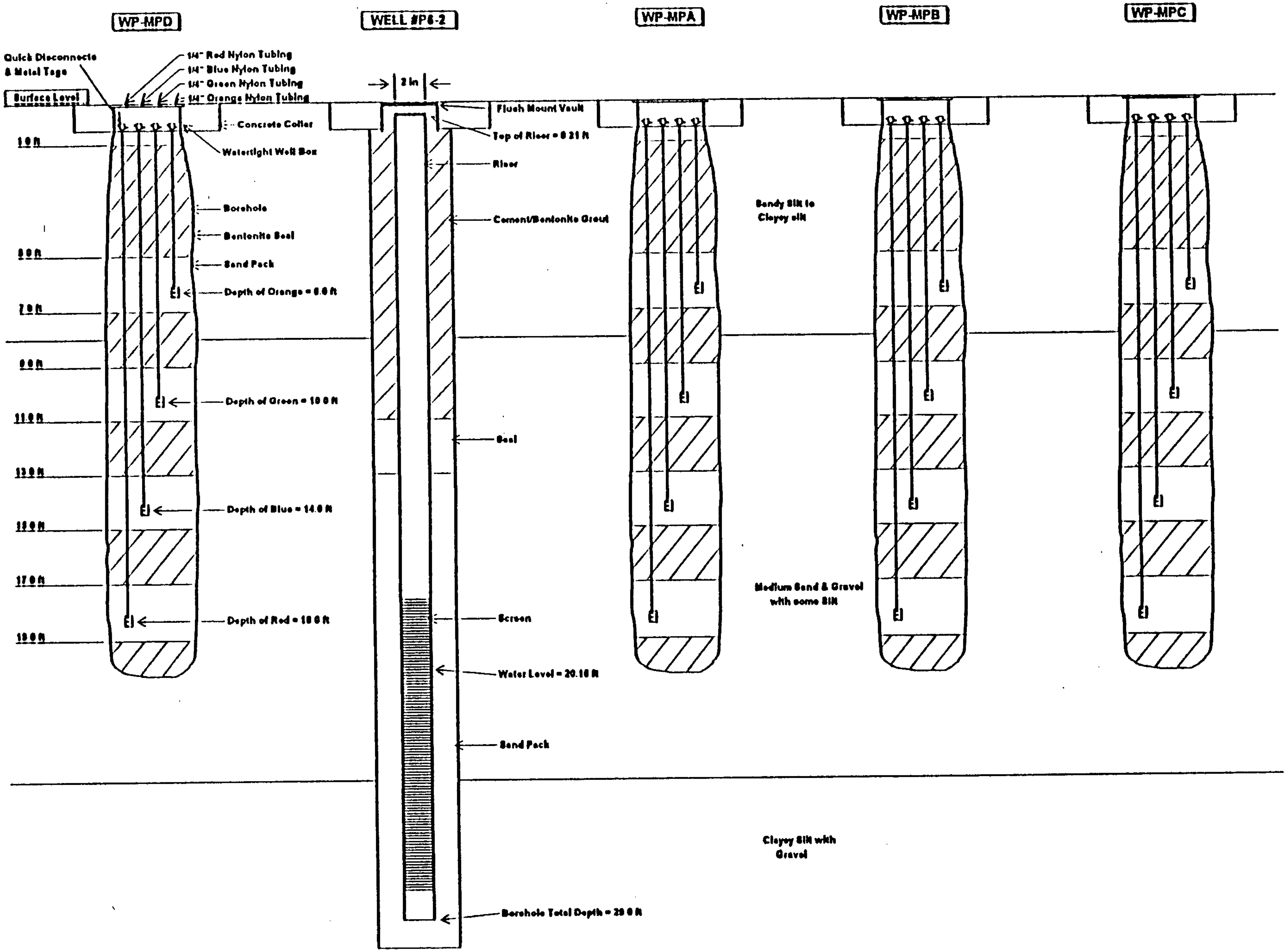


Figure 2. Bioslurper Short-Term Pilot Test Monitoring Point Installation Detail

3.0 BIOSLURPER SHORT-TERM PILOT TEST METHODS

This section describes the test equipment and methods used for the short-term pilot test at WPAFB and documents the initial conditions at the test site.

3.1 Initial LNAPL/Groundwater Measurements and Baildown Testing

Well #P6-2 was selected for installation of the test equipment because it was the only well at the project test site that had measurable LNAPL content. Initial LNAPL thickness measurements and depth to groundwater were measured using an oil/water interface probe (ORS Model #1068013). LNAPL was removed from the well with a teflon bailer until the LNAPL thickness could no longer be reduced. The rate of increase in the thickness of the floating LNAPL layer in the well was monitored for 22 hours using the oil/water interface probe (see Table 3 in Section 4.1 Baildown Test Results).

3.2 Monitoring Point and Thermocouple Installation

On October 25, 1994, four monitoring points (MP) were installed in the area of extraction well #P6-2. They were labeled WP-MPA, WP-MPB, WP-MPC, and WP-MPD. Figure 2 is a cross section of the monitoring points and shows site lithology and construction detail.

A soil-gas sample collection probe, connected to ¼-in. tubing, was used to establish each sampling level in a monitoring point. The soil-gas probe was 1-in. in diameter and had a 6-in. screened effective gas collection length. The probe was positioned at the appropriate depth, and then the annular space corresponding to the screened length of the soil gas sample collection probe was filled with silica sand. The interval between the screened lengths was filled with bentonite clay chips, as was the space from the top of the shallowest monitoring point up to the ground surface. After placement, the bentonite clay was hydrated to expand the chips and provide a seal. The soil gas probes in the monitoring points were installed at depths as follows.

- Monitoring Point WP-MPA was installed 10 ft south of well #P6-2 in a 6-in. diameter borehole to a depth of 22.5 ft. Sampling points were placed at four depths in the monitoring point: 6.0, 10.0, 14.0 and 18.0 ft.

- Monitoring Point WP-MPB was installed 21 ft south of well #P6-2 in a 6-in. diameter borehole to a depth of 20.5 ft. Sampling points were placed at four depths in the monitoring point: 6.0, 10.0, 14.0 and 18.0 ft.

- Monitoring Point WP-MPC was installed 60 ft south of well #P6-2 in a 6-in. diameter borehole to a depth of 20.5 ft. Sampling points were placed at four depths in the monitoring point: 6.0, 10.0, 14.0 and 18.0 ft.

- Monitoring Point WP-MPD was installed 39 ft north of well #P6-2 in a 6-in. diameter borehole to a depth of 20.5 ft. Sampling points were placed at four depths in the monitoring point: 6.0, 10.0, 14.0 and 18.0 ft.

Type K thermocouples were installed in monitoring point WP-MPA at 6.0, 14.0 and 18.0 ft. deep.

3.3 Soil Sampling and Analyses

Four soil samples were collected during the installation of WP-MPA because this point was closest to the extraction well #P6-2. The soil samples were collected in the depth range 19.5-22.5 ft. by means of brass sleeves driven down the center of the hollow stem auger used to drill monitoring point A. The samples were labeled as follows: WPA-19.5-21.0, WPA-20.0-20.5, WPA-21.0-22.5, and WPA-21.5-22.0. The samples were placed in insulated coolers, chain of custody records and shipping papers were completed, and the samples were sent to Alpha Analytical, Inc., Sparks, Nevada by overnight air express. Samples WPA-20.0-20.5 and WPA-21.5-22.0 were analyzed for benzene, toluene, total xylenes, and ethylbenzene (BTEX); TPH; alkalinity; pH; moisture content; total Kjeldahl nitrogen; total phosphorous and total iron; density; and porosity. Samples WPA-19.5-21.0, WPA-21.0-22.5, and WPA-21.5-22.0 were analyzed for particle size.

3.4 Soil Gas Sampling and Analyses

After installation of the monitoring points, initial soil gas measurements were taken with a GasTech Brand O_2/CO_2 meter and a GasTech Brand Tracetechtor Hydrocarbon meter. The initial soil gas compositions are shown in Table 1.

Table 1. Initial Soil Gas Compositions at Wright-Patterson AFB Spill Site 5

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppm)
WP-MPA	6.0	21.0	0.5	58
	10.0	20.5	1.9	180
	14.0	17.0	3.9	220
	18.0	8.5	10.5	100
WP-MPB	6.0	19.0	2.1	195
	10.0	19.1	3.5	220
	14.0	15.5	6.0	250
	18.0	8.0	11.0	240
WP-MPC	6.0	N/A	N/A	N/A
	10.0	19.5	2.5	190
	14.0	17.5	3.9	220
	18.0	13.5	6.9	260
WP-MPD	6.0	N/A	N/A	N/A
	10.0	20.5	0.5	20
	14.0	17.0	2.9	150
	18.0	19.5	2.0	210

N/A = Not available, sample could not be taken.

3.5 System Shakedown

The bioslurping pilot test system is a trailer-mounted mobile unit. The vacuum pump, oil/water separator, and required support equipment were carried to the test location on the trailer. The trailer was located near well #P6-2, the well cap was removed, a coupling and tee were attached to the top of the well, and the dip tube was lowered into the well. The dip tube was attached to the vacuum pump. Different configurations of the tee and the placement depth of the dip tube allow operation in the bioslurping mode or simulation of skimmer pumping or drawdown pumping as described in Sections 3.7, 3.6, and 3.9, respectively.

A brief system startup test was performed prior to LNAPL recovery testing to ensure that all system components were working properly. The system checklist is shown in Appendix A. All site data and field testing information were recorded in a field notebook and then transcribed onto the pilot test data sheet shown in Appendix B.

3.6 Skimmer Pump Test

On October 26, 1994, the skimmer pump test was started. First, the oil/water interface was measured with the oil/water interface probe. The initial conditions for the skimmer test are shown in Table 2.

Table 2. Initial Conditions in Well #P6-2 for the Short-Term Bioslurper Test

Test	Test Start Date	Fuel Depth (ft)	Water Depth (ft)	Fuel Thickness (ft)
Baildown Test	October 21, 1994	20.57	20.69	0.12
Skimmer Pump Test	October 26, 1994	19.68	19.73	0.05
Bioslurper Test	October 27, 1994	20.12	20.15	0.03
Drawdown Pump Test	November 29, 1994	21.33	21.37	0.04

The pump used for all the pump tests was an Atlantic Fluidics Model A100, a 7.5-hp liquid ring pump. A diagram showing the configuration of the well and slurper tube for the skimmer pump test is shown in Figure 3. For the test, the extraction tube was set at the LNAPL/groundwater interface with the wellhead open to the atmosphere through a PVC connecting tee. Before the start of the test, the liquid ring pump and the oil/water separator (OWS) were primed with known amounts of groundwater and diesel fuel, respectively, to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and then the liquid ring pump was started to begin the skimmer test. The test was operated continuously for 22.4 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the skimmer pump test.

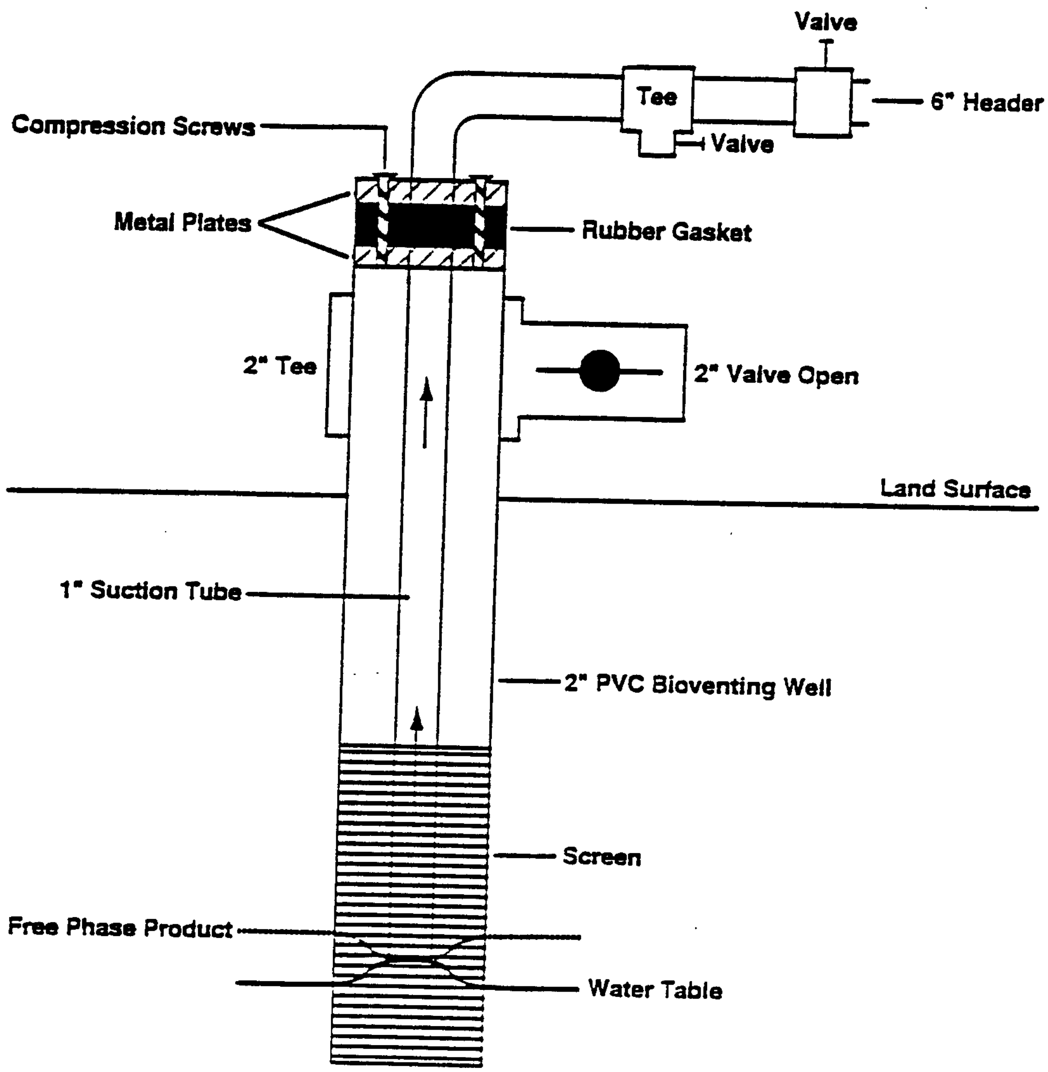


Figure 3. Slurper Tube Placement for the Skimmer Simulation Recovery Test

3.7 Bioslurper (Vacuum-Enhanced) Pump Test

Upon completion of the skimmer pump test, preparations were made to begin the bioslurper (vacuum-enhanced) pump test. Table 2 shows the initial conditions for the bioslurper pump test. Again, the oil/water interface in extraction well #P6-2 was measured first. The extraction tube was placed at the LNAPL/groundwater interface, just as it was in the skimmer pump test. However, in contrast to the skimmer pump test, the PVC connecting tee was removed, sealing the wellhead and allowing the vacuum pump to establish a vacuum in the well. A pressure gauge was installed at the wellhead to measure the vacuum inside the extraction well. The configuration of the well and slurper tube for the vacuum-enhanced pump test is shown in Figure 4. For this test, all product and groundwater flow totalizers were zeroed and reset so that the groundwater extraction and LNAPL recovery rates could be quantified accurately. Then the liquid ring pump was started to begin the bioslurper pump test. The short term bioslurper test was begun approximately 1.5 hours after completion of the skimmer test. The test was operated continuously for 98.2 hours (approximately 4 days). The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test.

3.8 Soil Gas Permeability Testing

The air permeability test data were collected during the bioslurping (vacuum-enhanced) pumping operation. Before a vacuum was established in the extraction well, the initial soil-gas pressures at the four installed monitoring points were recorded. The start of the bioslurping test created a step pressure drop in the extraction well; the drop in pressure was the beginning of the soil gas permeability testing. Soil gas pressures were measured in each of the four monitoring points at all depths to track the rate of outward propagation of the pressure drop in the extraction well. Soil gas pressure data were collected frequently during the first 20 minutes of the test. Thereafter, the data were collected less frequently, depending on the rate of the pressure change. Soil gas pressures were recorded throughout the bioslurper pump test to determine the bioventing radius of influence.

3.9 Drawdown Pump Test

After the 4 days of testing in the bioslurper pump mode, the test was halted and preparations

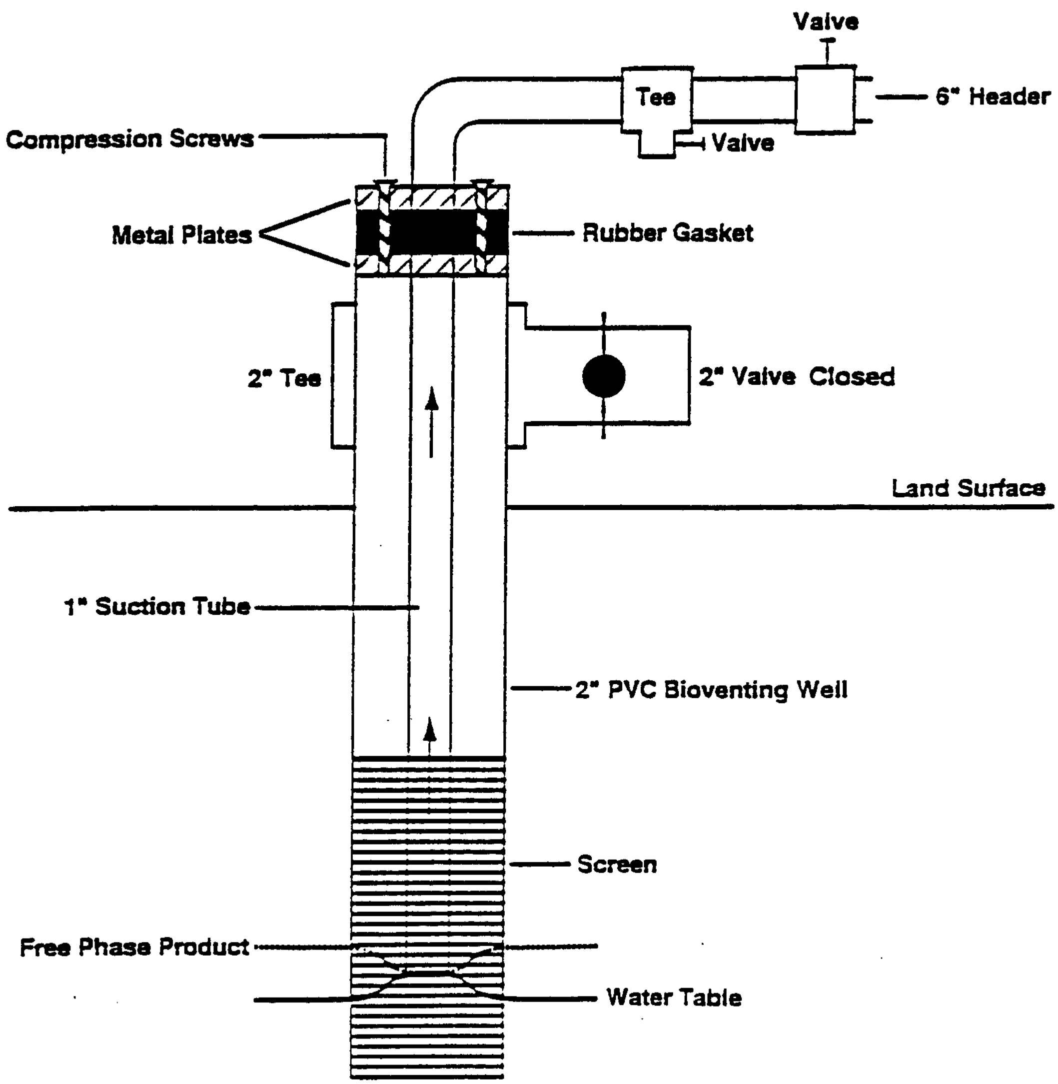


Figure 4. Slurper Tube Placement for the Bioslurper (Vacuum-Enhanced) Recovery Test

were made for the drawdown pump test. The PVC connecting tee was reinstalled on the wellhead so that the well was again open to the atmosphere. The depth to the oil/water interface was measured, and the extraction tube was placed so that the tube tip was 3 ft below the measured level of the oil/water interface. This tube placement creates a cone of groundwater depression around the extraction well to induce LNAPL flow for the drawdown pumping test. A diagram showing the general configuration of the drawdown pump test is depicted in Figure 5.

Approximately 3 hours into the test, the liquid ring pump shut off, apparently due to the power required to create the cone of depression. It was determined also that it was necessary to empty the holding tanks for extracted groundwater before initiating the drawdown test. The test was delayed for 3 weeks while adjustments were made to the liquid ring pump. On November 29, 1994, with the necessary changes made to the equipment and the holding tanks emptied, the drawdown pump test was restarted. Initial conditions for the drawdown pump test are shown in Table 2. The test was run for 22 hours. All LNAPL and groundwater flow totalizers were reset, and initial measurements were made to determine the drawdown pump test initial conditions. The LNAPL recovery rates and groundwater extraction rates were quantified over time, and all data needed to assess drawdown pump test efficiency were recorded. The data collected for all three tests performed at Wright-Patterson are summarized in Appendix B.

3.10 In Situ Respiration Testing

Air containing approximately 2% helium was injected into the soil at the short-term pilot test area for approximately 24 hours, beginning on November 3, 1994. The setup for the in situ respiration test is described in the *Test Plan and Technical Protocol for Bioventing* (Hinchee et al., 1992). A ½-hp diaphragm pump was used for air and helium injection. Air and helium were injected through the following monitoring points at the depths indicated: WP-MPA: 14.0', WP-MPB: 18.0', WP-MPC: 18.0', and WP-MPD: 18.0'. After the air/helium injection ceased, respiration gases were monitored periodically. The respiration test was terminated on November 7, 1994.

Helium concentrations were measured during the in situ respiration test to quantify soil gas movement around the monitoring points. Any helium loss over time is attributable directly to either diffusion through the soil or leakage. A rapid drop in helium concentration usually indicates leakage through the monitoring point. A gradual loss of helium over time indicates gas transport by diffusion. When the oxygen concentration decreases faster than the helium concentration, the loss of oxygen is

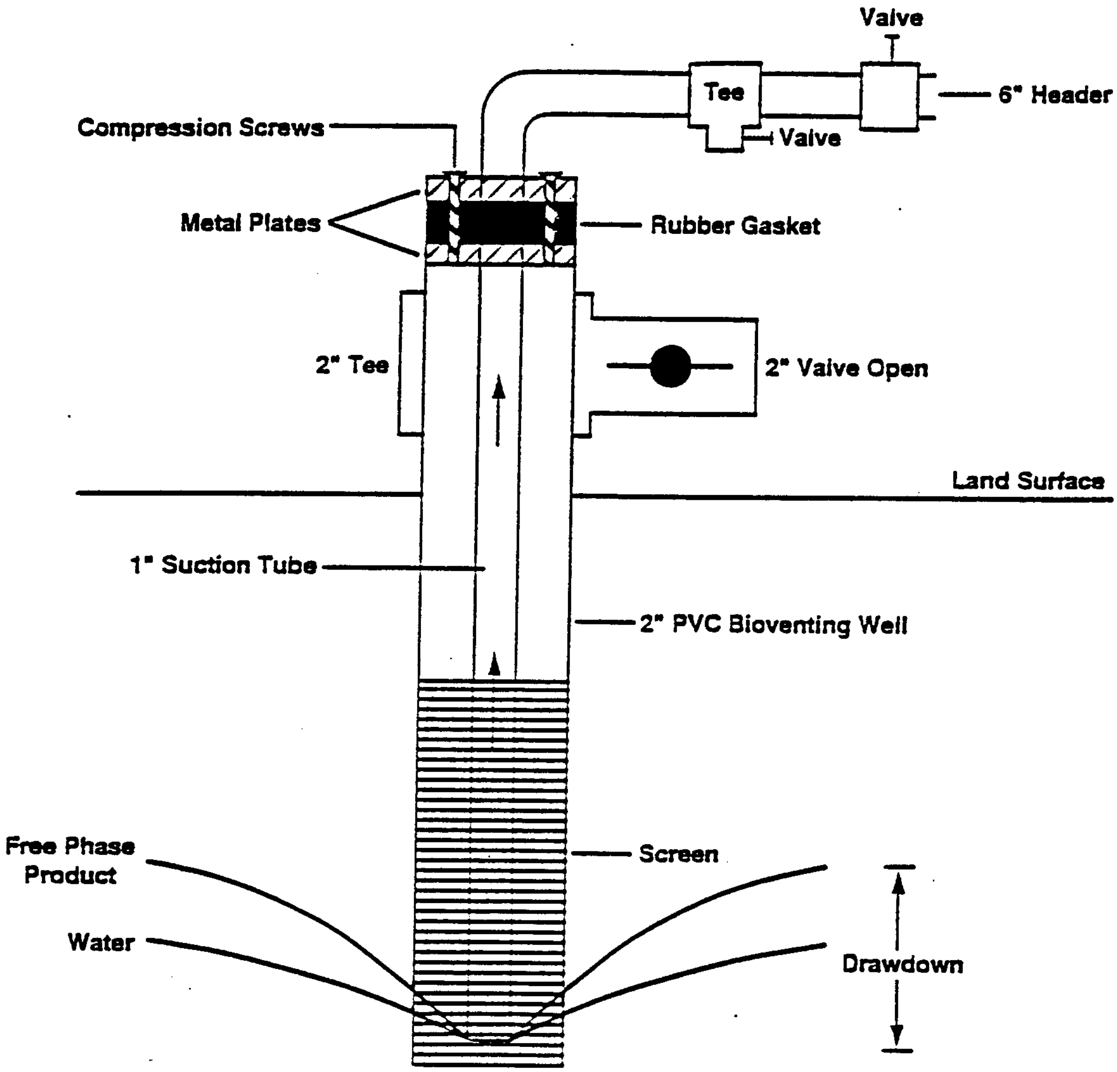


Figure 5. Slurper Tube Placement for the Drawdown Simulation Recovery Test

attributed to biological degradation of hydrocarbons (unless the soil chemical oxygen demand is unusually high). The decrease in oxygen concentration can be used to determine the biodegradation rate in terms of mg as a hexane equivalent per kg of soil per day.

3.11 Slug Testing

The slug tests were performed at the short-term pilot test area on December 22, 1994. Slug testing was performed in the extraction well used for the pilot testing (well #P6-2) and in a second well located at the short-term pilot test area (well #P6-1). The results of the slug tests help quantify the hydraulic properties of the test well and the aquifer near the well. The slug tests were done by creating an instantaneous change in head in the perspective well. The instruments used to perform the slug tests were a pressure transducer (Model PDX-260) and a Hermit Model SE2000C data logger, both of which are manufactured by In Situ, Inc. The slug test was then done by dropping a weighted 3-ft PVC tube (the slug) to displace the well water. After equilibrium was obtained in the well, the slug (PVC tube) was quickly removed and the Hermit data logger was started to record the head pressure above the transducer. The test was stopped once the amount of head above the transducer reached its original level (i.e., the reference level).

4.0 RESULTS

This section documents the results of the preliminary site characterization, the comparative LNAPL recovery pumping studies, and other supporting tests conducted at the WPAFB site.

4.1 Baildown Test Results

The initial LNAPL thickness observed in Well #P6-2 was 0.12 ft. A total volume of 0.157 gal was removed by hand bailing. LNAPL thickness recovered to 0.14 ft. after about 19 hours, and recovered no further during the remainder of the test (see Table 3).

Table 3. Results of Baildown Test in Well #P6-2

Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
Initial Reading (10/21/94 10:00)	20.69	20.57	0.12
10/21/94 10:10	20.64	20.60	0.04
10/21/94 12:00	20.70	20.59	0.11
10/21/94 14:00	20.73	20.56	0.18
10/21/94 18:46	20.72	20.58	0.14
10/22/94 8:40	20.74	20.60	0.14

Total Volume Bailed: 0.157 gal

At WPAFB, the amount of fuel in well #P6-2 was limited. Measurements of free product thickness could vary by as many as 1 to 1.5 inches depending on weather conditions and the subsurface aquifer's migration pattern. This could explain the difference in recorded thickness measurements of the LNAPL and the water table elevation in well #P6-2 (see Tables 2 and 3).

4.2 Soil Sample Analyses

Table 4 shows the BTEX and TPH content measured in soil samples from the short-term pilot test area. The laboratory analytical report for the soil samples is shown in Appendix C. The concentrations of BTEX compounds in the soil samples were below the detection limit. The purgeable TPH concentration in the soil samples ranged from below the detection limit to 1,800 mg/kg. The sieve analyses of the soil samples (see Table 5) indicate that site soil consists of about 25% gravel, 73% sand, and 2% silts and clay. The results of the soil chemistry analyses are summarized in Table 6.

Table 4. Analysis of Soil Samples Taken from Monitoring Point A at Bioslurper Test Site, Wright-Patterson AFB

Depth (ft)	Parameter	Detection Limit (mg/kg)	Concentration (mg/kg)
20.0 - 20.5	TPH (Purgeable)	10	ND
	Benzene	0.02	ND
	Toluene	0.02	ND
	Total Xylenes	0.02	ND
	Ethyl Benzene	0.02	ND
21.5 - 22.0	TPH (Purgeable)	200	1,800
	Benzene	0.4	ND
	Toluene	0.4	ND
	Total Xylenes	0.4	ND
	Ethyl Benzene	0.4	ND

ND = Non Detectable
* = Analysis performed by Alpha Analytical, Inc.

Table 5. Soil Sieve Analysis of Soil Samples Taken from Monitoring Point A at Bioslurper Pilot Test Site, Wright-Patterson AFB.

Depth (ft)	Density (g/cm^3)	Porosity (%)	U.S. Standard Sieve Size	Cumulative % Passing
19.5 - 21.0	1.6	38.9	1 in.	100
			½ in.	97
			No. 4	85
			No. 8	71
			No. 10	67
			No. 16	58
			No. 30	38
			No. 40	24
			No. 50	17
			No. 100	11
			No. 200	7
21.0 - 22.5	1.7	35.5	1 in.	100
			½ in.	86
			No. 4	65
			No. 8	52
			No. 10	48
			No. 16	38
			No. 30	25
			No. 40	15
			No. 50	11
			No. 100	5
			No. 200	<1

* = Analysis performed by Alpha Analytical, Inc.

Table 6. Soil Makeup Analysis of Soil Samples Taken From Monitoring Point A at Bioslurper Site, Wright-Patterson AFB

Depth	Alkalinity (mg/g)	pH (S.U.)	Moisture Content (%)	Kjeldahl Nitrogen (mg/g)	Total Phosphorous (mg/kg)	Total Iron (mg/kg)
20.0 - 20.5	14,121	9.03	7.2	2.9	<0.1	4,400
21.5 - 22.0	11,804	8.90	7.8	3.4	<0.1	5,600

* = Analysis performed by Alpha Analytical, Inc.

4.3 Pilot LNAPL Recovery Test Results

The skimmer pump, bioslurper pump, and drawdown pump test data are summarized in Table 7. LNAPL recovery versus time is plotted on Figure 6 for each test configuration. Results for each test configuration are discussed below.

Table 7. Bioslurper Pilot Study at Wright-Patterson AFB, Ohio, Extraction Well #P6-2

Data Item	Skimmer Pump Test		Bioslurper Test		Drawdown Test	
Test Duration (days)	0.933		4.09		0.917	
	LNAPL	Water	LNAPL	Water	LNAPL	Water
Total Recovered (gal)	3.75	775	19.00	7,819.6	2.25	2,605.5
Recovery Rate in Day 1 (gal/day)	4.01	830	11.3	2,699.5	2.45	2842.4
Recovery Rate in Day 2 (gal/day)	NA	NA	3.6	1,229.8	NA	NA
Recovery Rate in Day 3 (gal/day)	NA	NA	2.1	1,423.4	NA	NA
Recovery Rate in Day 4 (gal/day)	NA	NA	1.6	2,191.5	NA	NA
Average Recovery Rate (gal/day)	4.01	830	4.65	1,912	2.45	2842.4

NA = Skimmer and drawdown tests were conducted for one day each

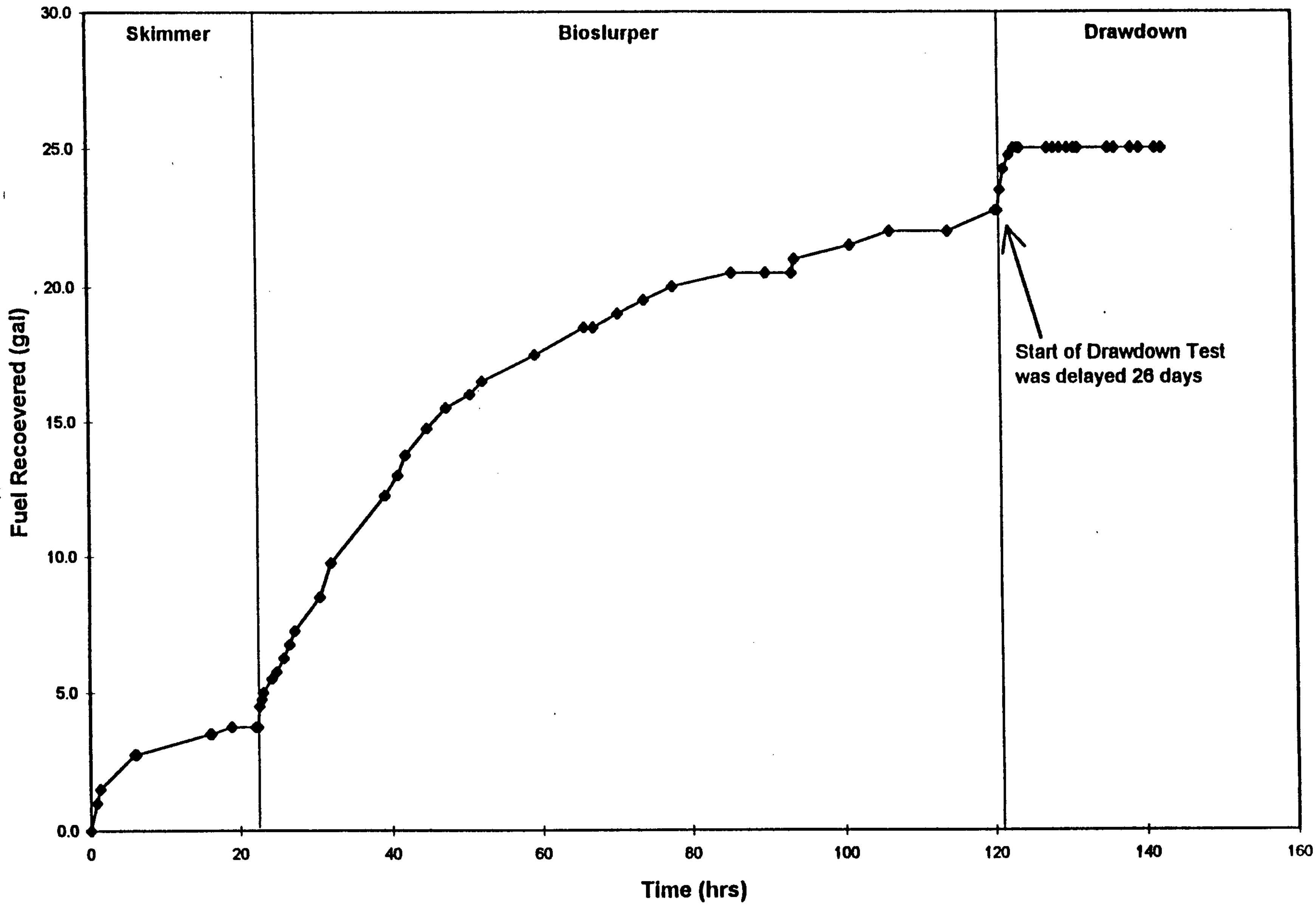


Figure 6. Total LNAPL Recovery as a Function of Time Through the Test Sequence

4.3.1 Skimmer Test Results

The bioslurper system was operated in the skimmer simulation configuration for approximately 1 day (22.4 hours). A total of 3.75 gal of LNAPL and 775 gal of groundwater were recovered during the test. Daily recovery averages compute to 4.01 gal/day for LNAPL and 830 gal/day for groundwater.

As Figure 6 indicates, the rate of LNAPL recovery during the skimmer test reduced to near 0.0 gal/day by the end of the 1-day test, as indicated by the decrease in slope of the recovery curve. During the first 16 hours of the test, a total of 3.5 gal of LNAPL was recovered; this equates to 5.25 gal per day. During the last 6.4 hours of the skimmer test an additional 0.25 gal of LNAPL had been recovered, equating to 0.94 gal/day. The final two measurements taken during the last 3.5 hours of the test indicated that no additional LNAPL had been recovered.

4.3.2 Bioslurper (Vacuum-Enhanced) Test Results

Immediately after the skimmer simulation test, the bioslurper system was reconfigured to the vacuum-enhanced operation mode. The vacuum-enhanced recovery test was started 0.5 hours after the skimmer test was completed. The initial measurements of LNAPL thickness are recorded in Table 2, and it appears that the well was able to recover the level of LNAPL seen prior to the skimmer test.

The bioslurper system was operated in the vacuum-enhanced configuration for approximately 4 days (98.1 hours). A total of 19.0 gal of LNAPL and 7,819.6 gal of groundwater were recovered during the test. Daily recovery averages compute to 4.65 gal/day for LNAPL and 1,912 gal/day for groundwater.

The vacuum-exerted wellhead pressure on extraction well #P6-2 was maintained at approximately 16 in. H_2O throughout the bioslurper pump test. This provides for an equivalent hydraulic gradient increase to a 16-in. groundwater depression in the well.

As illustrated by the sharp increase in slope of the recovery vs. time graph (Figure 6), the rate of LNAPL recovery increased rapidly immediately after the vacuum-enhanced test was initiated. The sudden increase in recovery rate indicates that LNAPL, although not mobile during the skimmer test, was mobilized to the well under vacuum-enhanced conditions. As observed during the skimmer test, the recovery rate decreased with time during the vacuum-enhanced pilot test. Table 7 presents recovery rates for LNAPL and groundwater for each day of the bioslurper test.

As Table 7 shows, the LNAPL and groundwater recovery rates for day 1 of the vacuum-enhanced test were 11.3 gal/day and 2699.5 gal/day, respectively. Day 2 recovery rates dropped to 3.6 gal/day for LNAPL and 1229.8 gal/day for groundwater. On Day 3, the LNAPL recovery rate was 2.1 gal/day, and groundwater recovery was 1423.4 gal/day. By Day 4, LNAPL recovery was 1.6 gal/day with groundwater recovery at 2191.5 gal/day. Although LNAPL recovery rates reduced each day of the vacuum-enhanced pilot test, it appears that LNAPL recovery had reached near steady-state conditions by the 3rd and 4th days of the test. Figure 7 shows the relationship between LNAPL recovery rate and time during the four days of bioslurper testing. Groundwater recovery rates varied widely throughout the test because of heavy rain during testing.

The vapor discharged during the bioslurper test was sampled and analyzed. The vapor discharge rate for the bioslurper test was approximately 7,500 ft^3/day (5.2 cfm). Based on the analyses and vapor discharge rate, approximately 1.04 lbs/day of TPH was emitted to the air during the bioslurper test. Carbon dioxide and oxygen measurements also were recorded during the bioslurper testing and are shown in Table 12.

4.3.3 Drawdown LNAPL Recovery Test

As stated in Section 3.9, the drawdown pump test was delayed approximately 3 weeks due to difficulty with extracted groundwater disposition. The bioslurper system was configured for the drawdown simulation mode on November 29, 1995, and the drawdown pump test was initiated.

The bioslurper system was operated in the drawdown simulation configuration for approximately 1 day (22.0 hours). A total of 2.25 gal of LNAPL and 2605.5 gal of groundwater were recovered during the test. Daily recovery averages compute to 2.46 gal/day for LNAPL and 2842.4 gal/day for groundwater.

As Figure 6 indicates, the rate of LNAPL recovery during the drawdown test reduced to near 0.0 gal/day by the end of the 1-day test, as indicated by the decrease in slope of the recovery curve. During the first 2.5 hours of the test, a total of 2.25 gal of LNAPL was recovered; this equates to 21.3 gal per day. During the last 19.5 hours of the drawdown test, no additional LNAPL was recovered, equivalent to 0.0 gal/day.

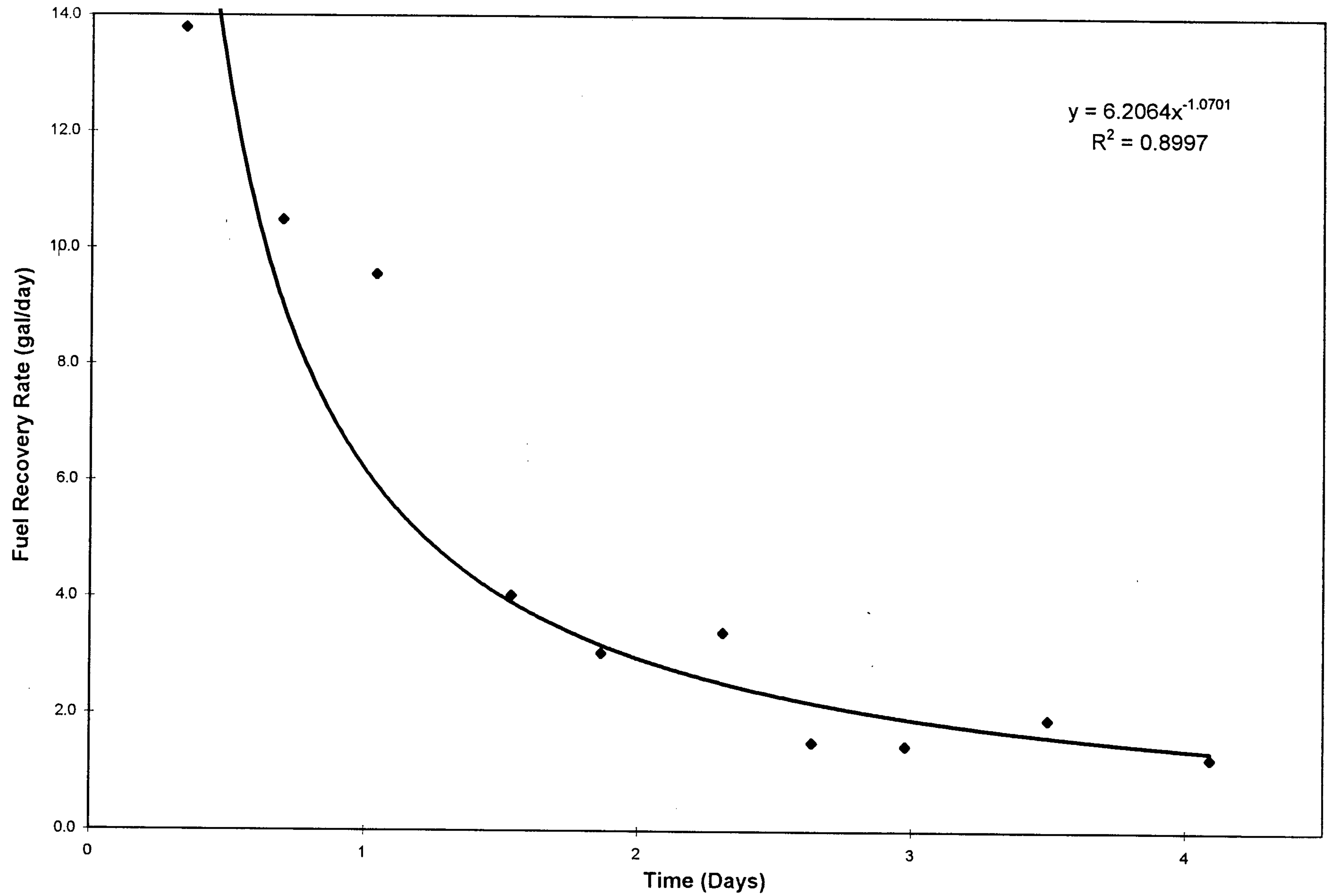


Figure 7. LNAPL Recovery Rate as a Function of Time Through the Bioslurper Test Sequence

4.4 LNAPL, Groundwater Discharge, and Vapor Discharge Analyses

During the operation of the bioslurper pump test, water and fuel samples from the oil/water separator were collected. These fuel and water samples was analyzed by Alpha Analytical, Inc. The fuel composition is shown in Tables 8 and 9. The distribution of organic compounds by number of carbons is shown in Figure 8. The contaminant concentration in the water from the oil water separator is shown in Table 10. Vapor samples also were collected from the bioslurper system vapor discharge stack. The analysis of the vapor samples was done by Air Toxics, Inc. The results from the vapor discharge samples are shown in Table 11. The laboratory analytical reports for all analyses are shown in Appendix C.

Table 8. BTEX Analysis of Fuel Recovered from Well #P6-2, Bioslurper Pilot Test, Wright-Patterson AFB

Compound	Method	Detection Limit (mg/kg)	Concentration* (%)
Benzene	8240	40	ND
Toluene	8240	40	0.09
Total Xylenes	8240	40	1.0
Ethylbenzene	8240	40	0.18

ND = Non Detectable
* = Analysis Performed by Alpha Analytical, Inc.

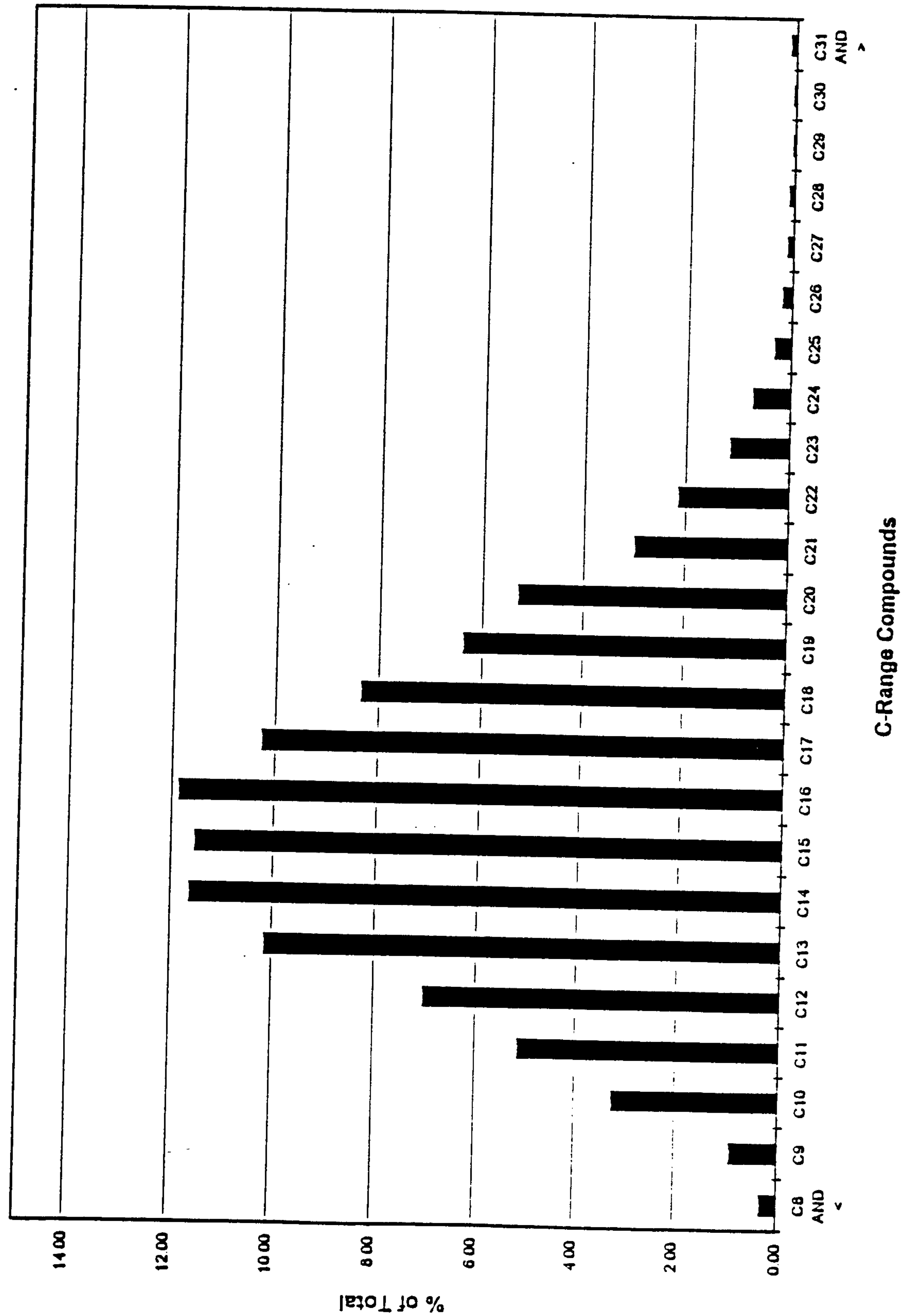


Figure 8. Percentage Distribution of Organic Compounds in Recovered LNAPL

Table 9. C-Range Compound Analysis of Fuel Recovered from Well #P6-2, Bioslurper Pilot Test, Wright-Patterson AFB

C-Range Compounds	Method	Percentage of Total
C8 and <	GC/FID	0.32
C9	GC/FID	0.92
C10	GC/FID	3.25
C11	GC/FID	5.14
C12	GC/FID	7.03
C13	GC/FID	10.14
C14	GC/FID	11.64
C15	GC/FID	11.54
C16	GC/FID	11.86
C17	GC/FID	10.25
C18	GC/FID	8.34
C19	GC/FID	6.36
C20	GC/FID	5.29
C21	GC/FID	3.00
C22	GC/FID	2.14
C23	GC/FID	1.16
C24	GC/FID	0.72
C25	GC/FID	0.32
C26	GC/FID	0.19
C27	GC/FID	0.11
C28	GC/FID	0.09
C29	GC/FID	0.04
C30	GC/FID	0.04
C31 and >	GC/FID	0.11

* = Analysis Performed by Alpha Analytical, Inc.

Table 10. Analysis of Groundwater Samples Taken from Oil/Water Separator Water Discharge Stream During Bioslurper Pilot Test, Wright-Patterson AFB

Sample	Day of Test	Parameter	Detection Limit (mg/L)	Concentration (mg/L)
GW-1-WP	1	TPH (Purgeable)	0.50	ND
		Benzene	0.001	ND
		Toluene	0.001	ND
		Total Xylenes	0.001	ND
		Ethylbenzene	0.001	ND
GW-2-WP	2	TPH (Purgeable)	0.50	ND
		Benzene	0.001	ND
		Toluene	0.001	ND
		Total Xylenes	0.001	ND
		Ethylbenzene	0.001	ND

ND = Non Detectable
* = Analysis performed by Alpha Analytical, Inc.

Table 11. Analysis of Discharge Vapor Samples Taken from Bioslurper Stack, Bioslurper Pilot Test, Wright-Patterson AFB

Sample	Day of Test	Compound Analyzed For	Method	Detection Limit (ppmv)	Concentration (ppmv)
SG-1-WP	2	TPH (as jet fuel)	GC/FID	0.16	220
		Benzene	GC/PID	0.016	ND
		Toluene	GC/PID	0.016	ND
		Total Xylenes	GC/PID	0.016	1.2
		Ethylbenzene	GC/PID	0.016	4.1
SG-2-WP	3	TPH (as jet fuel)	GC/FID	1.0	970
		Benzene	GC/PID	0.10	ND
		Toluene	GC/PID	0.10	ND
		Total Xylenes	GC/PID	0.10	6.4
		Ethylbenzene	GC/PID	0.10	20

4.5 Slug Test Results

Figure 9 is a graph of one of the slug tests performed at the short-term pilot test area. The raw data and replicate slug test data and results are shown in Appendix F. The results of the slug tests indicate that the hydraulic conductivity of the area surrounding well #P6-2 was 6.53 ft per day. As stated previously, the soils in the area are composed mostly of sands (about 73%). Information obtained from literature sources indicates that the hydraulic conductivity falls within the upper range of sand. The intent of the slug test is to compare the potentials of the various bioslurper initiative test sites to recover LNAPL into the perspective extraction wells being used.

4.6 Bioventing Analyses

4.6.1 Soil Gas Permeability and Radius of Influence

The radius of influence is calculated by plotting the log of the pressure change at a specific monitoring point versus the distance from the extraction well. The radius of influence is defined as the distance from the extraction well where 0.01 in. of H_2O can be measured. Therefore, the radius of influence based on these specifications is 49 ft (see Figure 10). The raw data collected during the soil gas permeability test are shown in Appendix D.

4.6.2 In Situ Respiration Test

The raw data collected during the in situ respiration test are given in Appendix E. Figure 11 illustrates the variation of soil gas composition with time during an in situ respiration test. Changes in the concentrations of oxygen, carbon dioxide, and helium are indicated in Table 12. A summary of the oxygen utilization and carbon dioxide production rates and the corresponding biodegradation rates is shown as Table 13. The biodegradation rates measured at this site ranged from 1.3 to 3.2 mg/kg/day, based on oxygen utilization. The soil-gas composition in the monitoring points at various times during the vacuum-enhanced pumping operation is given in Table 14.

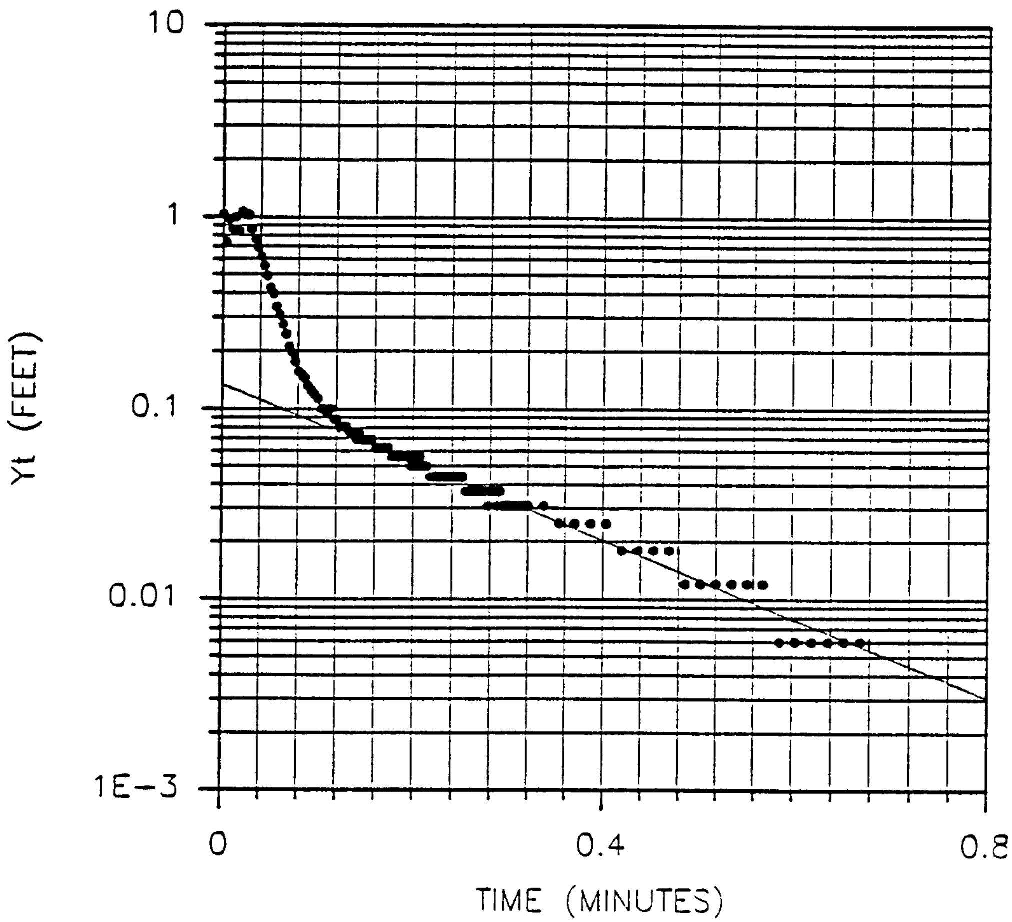


Figure 9. Level Variation During An Example Slug Test in Well #P6-2

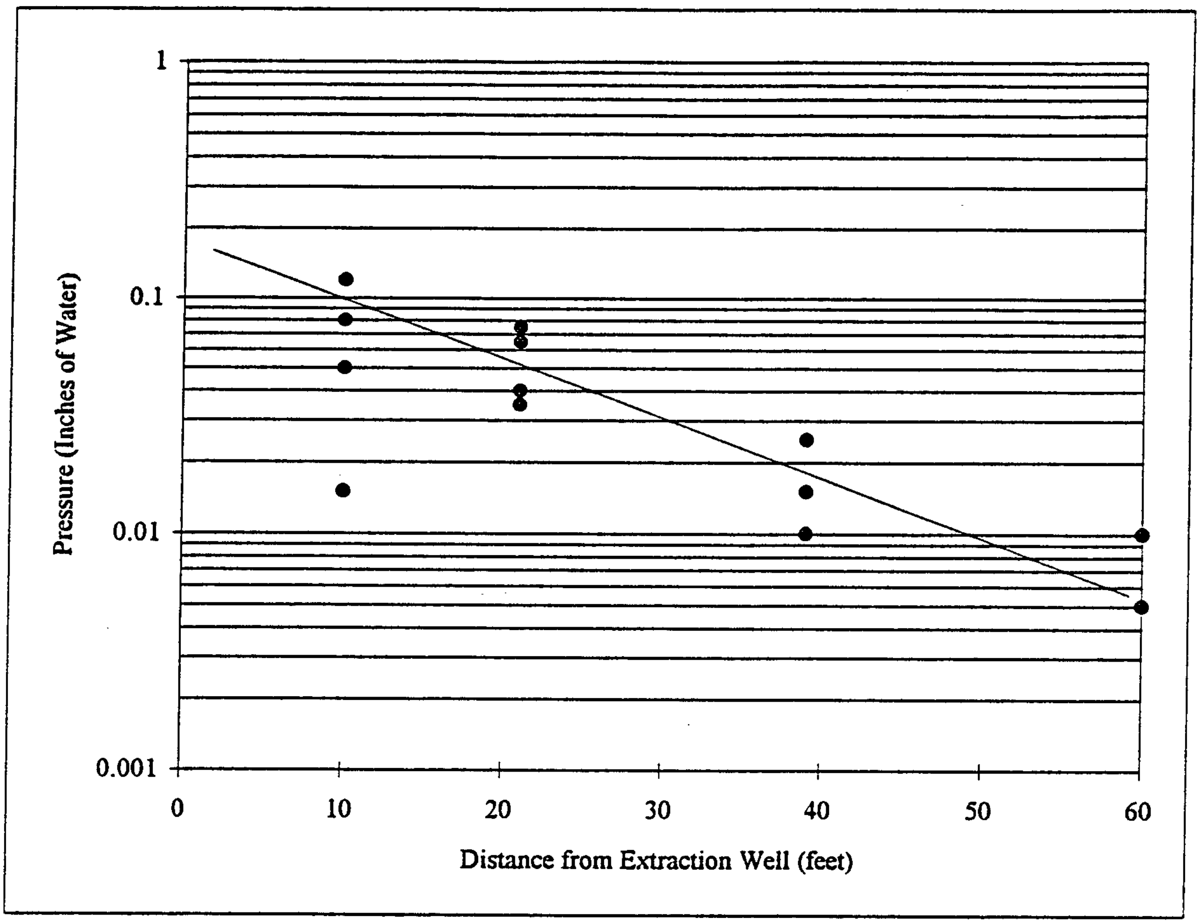


Figure 10. Soil Gas Pressure as a Function of Distance

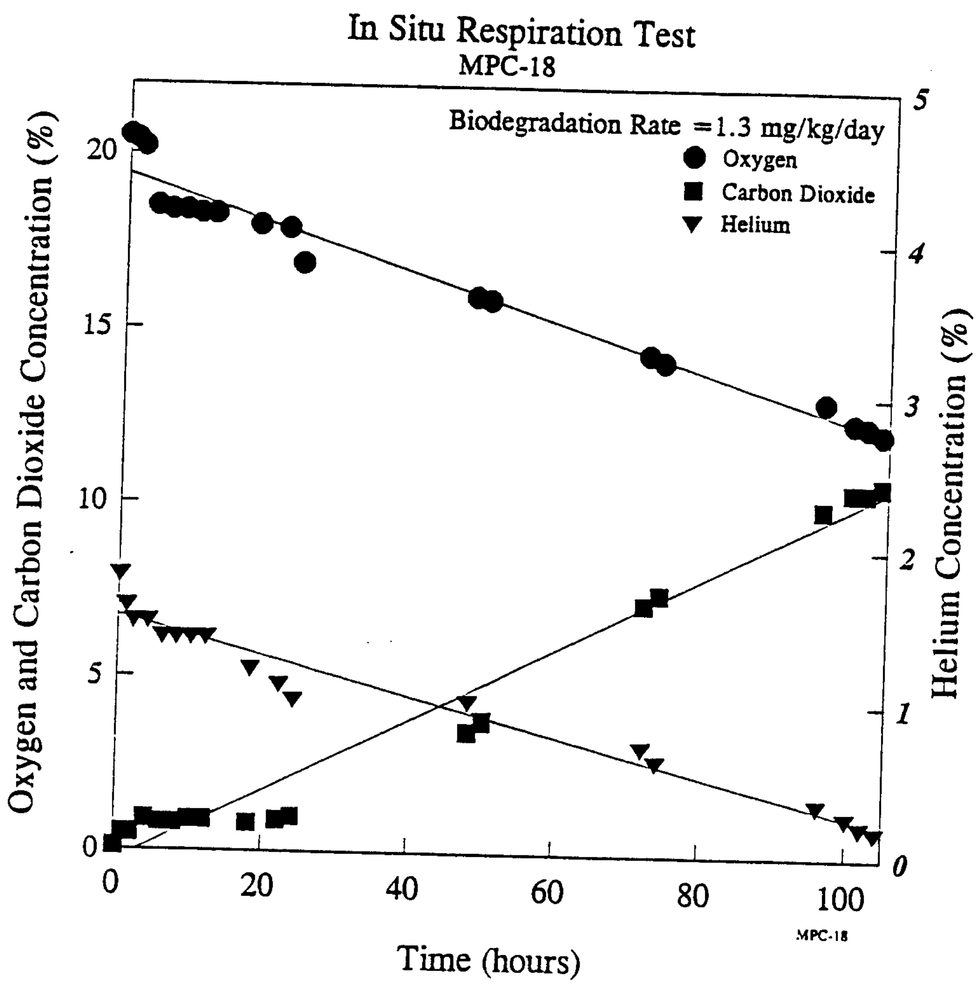


Figure 11. Soil Gas Composition Variation During an in Situ Respiration Test

Table 12. Carbon Dioxide and Oxygen Measurements in the Stack during Bioslurper Test

Date/Time	Carbon Dioxide in Stack during Bioslurping (%)	Oxygen in Stack during Bioslurping (%)
Oct 28 / 13:10	1.2	15.0
Oct 28 / 13:45	2.1	19.8
Oct 29 / 15:01	1.0	19.8
Oct 29 / 15:04	0.7	20.0
Oct 30 / 13:10	0.6	19.8
Nov 01 / 15:09	0.7	19.8

Table 13. Oxygen Utilization Rates During the In Situ Respiration Test at Wright-Patterson AFB.

Monitoring Point	Oxygen Utilization Rate (%/hr)	Biodegradation Rate (mg/kg/day)
WP-MPA-14	0.070	1.5
WP-MPB-18	0.098	2.1
WP-MPC-18	0.060	1.3
WP-MPD-18	0.149	3.2

Loss of helium was insignificant at all monitoring points, indicating that the monitoring points were well sealed and that the oxygen depletion observed was a result of biodegradation.

Table 14. Soil Gas Concentrations During the Bioslurper Test

	Time = 0 min		Time = 120 min		Time = 1518 min		Time = 5889 min	
	O_2 (%)	CO_2(%)	O_2 (%)	CO_2 (%)	O_2 (%)	CO_2 (%)	O_2 (%)	CO_2 (%)
MPA-6	18.0	1.5	20.0	1.0	20.0	0.0	20.0	0.0
MPA-10	11.5	6.5	19.0	3.5	19.5	1.9	20.0	1.1
MPA-14	8.0	9.2	13.5	5.5	18.0	2.5	19.0	1.9
MPA-18	2.5	15.0	7.0	13.0	9.0	9.0	11.0	8.5
MPB-6	13.0	3.0	19.0	1.5	20.0	0.5	20.0	0.0
MPB-10	12.0	5.5	16.5	5.0	18.5	4.5	18.0	3.9
MPB-14	8.3	8.8	10.0	8.8	12.0	7.0	13.0	6.0
MPB-18	3.5	13.0	5.0	12.0	5.5	11.0	9.5	9.0
MPC-6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MPC-10	13.0	3.2	16.0	3.0	16.0	3.8	20.0	0.2
MPC-14	11.8	6.9	17.5	2.8	18.0	1.8	19.5	1.5
MPC-18	8.5	9.0	10.0	8.5	10.5	7.5	9.5	7.0
MPD-6	18.2	2.5	N/A	N/A	N/A	N/A	N/A	N/A
MPD-10	15.0	3.0	20.0	2.0	20.0	0.6	20.0	0.0
MPD-14	9.5	8.0	17.0	6.5	18.0	2.0	20.0	0.5
MPD-18	2.0	15.5	8.0	12.8	8.0	10.5	10.0	10.0

N/A = Not Available

5.0 DISCUSSION OF RESULTS

LNAPL was recovered from Well #P6-2 during each LNAPL recovery configuration. However, the LNAPL recovery rates during the skimmer and pump drawdown recovery configurations reached near 0.0 gal/day by the end of each 1-day test. LNAPL recovery rate during the 4-day vacuum-enhanced recovery test decreased each day of the test but still was over 1.5 gal/day after 4 days. Clearly, LNAPL recovery was significantly enhanced by the application of the bioslurper/vacuum-enhanced recovery technology. In addition to increased LNAPL recovery, the vacuum-enhanced pilot test demonstrated that vadose zone oxygen concentrations were increased above oxygen-limited conditions in all monitoring points (see Table 14). In situ respiration testing indicated an average biodegradation rate of 2.0 mg/kg/day, or 730 mg/kg/year.

Implementation of bioslurping at the Wright-Patterson AFB pilot test site likely would facilitate enhanced recovery of LNAPL from the water table and simultaneous in situ biodegradation of hydrocarbons in the vadose zone via low-flow vapor extraction (bioventing). Feasibility of implementing bioslurping would depend on long-term requirements for vapor treatment (not required during the short-term test) and for disposing of extracted groundwater (1.3 gpm/well). Because vapor emission rate at the Wright-Patterson site would be approximately 1.04 lbs TPH/day, it would be possible to discharge the vapor dircetly to the atmosphere. However, due to the nature of the contamination, the wastewater generated from long-term bioslurper pumping still would need to be analyzed prior to disposal to base treatment facilities.

APPENDIX A

SYSTEM CHECKLIST

Checklist for System Shakedown

Site: WPAFB - C Street Parking Lot

Date: 10/25/94

Operator's Initials: ECD

Equipment	Check if Okay	Comments
Liquid Ring Pump	✓	
Aqueous Effluent Transfer Pump	✓	
Oil/Water Separator	✓	
Vapor Flow Meter	✓	
Fuel Flow Meter	✓	
Water Flow Meter	✓	
Emergency Shut off Float Switch -Effluent Transfer Tank	✓	
Analytical Field Instrumentation -GasTechtor O_2/CO_2 Analyzer -TraceTechtor Hydrocarbon Analyzer -Oil/Water Interface Probe -Magnehelic Boards -Thermocouple Thermometer	 ✓ ✓ ✓ ✓ ✓	 Calibrated O_2/CO_2 analyzer Calibrated TPH analyzer

APPENDIX B

DATA SHEETS FROM THE SHORT-TERM PILOT TEST

Wrig[illegible]n AFB B[illegible] Test Da[illegible]

Test : Skimmer Pump Test

Date/Time	Gen. Time (hr)	Time (min)	LNAPL Recovery Col. (gal)	LNAPL Recovery Total (gal)	Total LNAPL Flowrate (gpm)	Time Period LNAPL Flowrate (gpm)	Groundwater Removal Rate Col. (gal)	Groundwater Removal Rate Total (gal)	Total GW Flowrate (gpm)	Time Period GW Flowrate (gpm)	Diff. Stack Pressure (in H_2O)	Stack Temperature (deg C)	Pump Head Vacuum (in Hg)	Well Head Pressure (in H_2O)	Ambient Temperature (deg C)	Relative Humidity (%)	Barometric Pressure (in Hg)	O_2 (%)	Stack Gas CO_2 (%)	TPH (ppm)
Oct 26 / 1500	13.6	0	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00					14.7	35	29.78			
	14.4	48	1.00	1.00	0.02	0.02	29.0	29.0	0.60	0.60	0.08		19					20.0	1.0	160
	14.9	78	0.50	1.50	0.02	0.02	20.0	49.0	0.63	0.67	0.08		19							
	19.5	354	1.25	2.75	0.01	0.00	150.0	199.0	0.56	0.54	0.1		18							
	19.7	366	0.00	2.75	0.01	0.00	7.0	206.0	0.56	0.58	0.105									
	19.8	372	0.00	2.75	0.01	0.00	4.0	210.0	0.56	0.67	0.105		18							
Oct 27 / 0100	29.6	960	0.75	3.50	0.00	0.00	265.0	475.0	0.49	0.45					13.8	28	29.52			
	29.8	972	0.00	3.50	0.00	0.00	7.0	482.0	0.50	0.58	0.10		21							
	32.5	1134	0.25	3.75	0.00	0.00	150.0	632.0	0.56	0.93	0.175		17.3					19.8	0.8	130
	35.7	1326	0.00	3.75	0.00	0.00	130.0	762.0	0.57	0.68										
	36.0	1344	0.00	3.75	0.00	0.00	13.0	775.0	0.58	0.72	0.19		17							

Test : Vacuum Enhancement Pump Test

Date/Time	Gen. Time (hr)	Time (min)	LNAPL Recovery Col. (gal)	LNAPL Recovery Total (gal)	Total LNAPL Flowrate (gpm)	Time Period LNAPL Flowrate (gpm)	Groundwater Removal Rate Col. (gal)	Groundwater Removal Rate Total (gal)	Total GW Flowrate (gpm)	Time Period GW Flowrate (gpm)	Diff. Stack Pressure (in H_2O)	Stack Temperature (deg C)	Pump Head Vacuum (in Hg)	Well Head Pressure (in H_2O)	Ambient Temperature (deg C)	Relative Humidity (%)	Barometric Pressure (in Hg)	O_2 (%)	Stack Gas CO_2 (%)	TPH (ppm)
Oct 28 / 1300	36.5	0	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00					16.1	34	29.38			
	36.7	10	0.75	0.75	0.08	0.08	20.0	20.0	2.00	2.00	0.01	24.4	26					15.0	1.2	5600
	37.0	30	0.25	1.00	0.03	0.01	35.0	55.0	1.83	1.75	0.015	24.6	26							
	37.2	40	0.25	1.25	0.03	0.03	45.0	100.0	2.50	4.50	0.01	25.1	26							
	38.3	110	0.50	1.75	0.02	0.01	135.0	235.0	2.14	1.93	0.03	28.2	23	25						
	39.0	150	0.25	2.00	0.01	0.01	160.7	395.7	2.64	4.02	0.25	31.1	10	18						
	39.9	205	0.50	2.50	0.01	0.01	120.8	516.5	2.52	2.20	0.25	29.6	11	18						
	40.7	253	0.50	3.00	0.01	0.01	108.9	625.4	2.47	2.27	0.20	29.1	11	18						
	41.4	294	0.50	3.50	0.01	0.01	118.9	744.3	2.53	2.90	0.20	28.5	12	18						
	44.8	496	1.25	4.75	0.01	0.01	263.9	1008.2	2.03	1.31	0.01	28.3	11	17				19.8	2.1	4400
	46.2	584	1.25	6.00	0.01	0.01	261.5	1269.7	2.17	2.97			11	16						
	53.4	1011	2.50	8.50	0.01	0.01	469.6	1739.3	1.72	1.10	0.005		11	15						
	55.1	1115	0.75	9.25	0.01	0.01	220.3	1959.6	1.76	2.12	0.03	28.1	11	16						
	56.1	1174	0.75	10.00	0.01	0.01	194.9	2154.5	1.84	3.30										
	59.0	1347	1.00	11.00	0.01	0.01	444.9	2599.4	1.93	2.57	0.05	30.1	11	15						
Oct 29 / 1501	61.5	1501	0.75	11.75	0.01	0.00	214.5	2813.9	1.87	1.39		30.6	11	15	18.8	100	29.34	19.8	1.0	880
	64.7	1689	0.50	12.25	0.01	0.00	214.6	3028.5	1.79	1.14		30.0	11	15				20.0	0.7	360
	66.3	1789	0.50	12.75	0.01	0.01	59.6	3088.1	1.73	0.60		29.5	11	15						
	73.4	2215	1.00	13.75	0.01	0.00	188.0	3276.1	1.48	0.44	1.0	25.3	18*	15						
	80.1	2613	1.00	14.75	0.01	0.00	369.0	3645.1	1.39	0.93	2.0	27.9	16	16.5						
	81.3	2688	0.00	14.75	0.01	0.00	178.6	3823.7	1.42	2.38	0.25	29.9	16	17						
Oct 30 / 1306	84.6	2886	0.50	15.25	0.01	0.00	173.0	3996.7	1.38	0.87	0.30	31.4	16	17	24.0	100	29.20			
	88.1	3096	0.50	15.75	0.01	0.00	219.2	4215.9	1.36	1.04	0.50	30.9	16	18				19.8	0.8	500
	91.9	3323	0.50	16.25	0.00	0.00	470.4	4686.3	1.41	2.07	0.17	29.9	16	16.5						
	91.9	3325	0.00	16.25	0.00	0.00	2.0	4688.3	1.41	1.00										
	99.8	3795	0.50	16.75	0.00	0.00	291.0	4979.3	1.31	0.62	0.18	28.9	16	16.5						
	104.2	4060	0.00	16.75	0.00	0.00	212.3	5191.6	1.28	0.80										
	107.6	4265	0.00	16.75	0.00	0.00	140.5	5332.1	1.25	0.69	0.14	30.3	17	16.5						
	108.0	4287	0.50	17.25	0.00	0.02	49.4	5381.5	1.26	2.25										
Oct 31 / 2143	115.2	4723	0.50	17.75	0.00	0.00	502.4	5883.9	1.25	1.15	0.15	31.0	17	17	17.3	60	29.25			
	120.4	5036	0.50	18.25	0.00	0.00	778.4	6662.3	1.32	2.49										
	128.2	5501	0.00	18.25	0.00	0.00	343.0	7005.3	1.27	0.74										
Nov 01 / 1509	134.7	5869	0.75	19.00	0.00	0.00	814.3	7819.6	1.33	2.10	0.25	30.3	17	17	8.0	68	29.38	19.8	0.7	550

Test : Drawdown Pump Test

Date/Time	Gen. Time (hr)	Time (min)	LNAPL Recovery Col. (gal)	LNAPL Recovery Total (gal)	Total LNAPL Flowrate (gpm)	Time Period LNAPL Flowrate (gpm)	Groundwater Removal Rate Col. (gal)	Groundwater Removal Rate Total (gal)	Total GW Flowrate (gpm)	Time Period GW Flowrate (gpm)	Diff. Stack Pressure (in H_2O)	Stack Temperature (deg C)	Pump Head Vacuum (in Hg)	Well Head Pressure (in H_2O)	Ambient Temperature (deg C)	Relative Humidity (%)	Barometric Pressure (in Hg)	O_2 (%)	Stack Gas CO_2 (%)	TPH (ppm)
Nov 29 / 1400	185.2	0	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00					21.1	40	28.82			
	185.5	20	0.00	0.00	0.00	0.00	60.0	60.0	3.00	3.00	0.10	30.1	15	11				19.5	1.0	140
	185.9	40	0.75	0.75	0.02	0.04	76.0	136.0	3.40	3.80	0.10	29.9	19*	15						
	186.4	71	0.75	1.50	0.02	0.02	120.0	256.0	3.61	3.87	0.15	29.8	22*	16						
	187.1	115	0.50	2.00	0.02	0.01	123.0	379.0	3.30	2.80	0.175	29.6	23.5	16						
	187.7	152	0.25	2.25	0.01	0.01	105.0	484.0	3.18	2.84	0.15	29.4	19	16.5						
	188.2	181	0.00	2.25	0.01	0.00	95.0	579.0	3.20	3.28	0.15	28.8	22.5	16						
	188.5	200	0.00	2.25	0.01	0.00	60.0	639.0	3.20	3.16										
	192.2	421	0.00	2.25	0.01	0.00	497.3	1136.3	2.70	2.25	0.10	24.5	22	16.5				19.8	0.8	260
	193.0	469	0.00	2.25	0.00	0.00	105.6	1241.9	2.65	2.20	0.10	24.1	22	17						
	193.9	520	0.00	2.25	0.00	0.00	114.2	1356.1	2.61	2.24	0.15	23.9	23	17						
	194.9	580	0.00	2.25	0.00	0.00	126.0	1482.1	2.56	2.10	0.20	23.9	22	17						
Nov 30 / 0030	195.7	630	0.00	2.25	0.00	0.00	90.0	1572.1	2.50	1.80	0.20	23.8	23	16	16.2	28	29.01			
	196.2	661	0.00	2.25	0.00	0.00	44.3	1616.5	2.45	1.43										
	200.2	900	0.00	2.25	0.00	0.00	334.6	1951.1	2.17	1.40	0.25	23.4	22	16.5						
	201.0	950	0.00	2.25	0.00	0.00	80.5	2031.6	2.14	1.61	0.20	23.4	21	16						
	203.2	1082	0.00	2.25	0.00	0.00	205.9	2237.5	2.07	1.56	0.15	24.1	22	16						
	204.3	1145	0.00	2.25	0.00	0.00	105.2	2342.7	2.05	1.67	0.20	24.3	20	16						
	206.4	1273	0.00	2.25	0.00	0.00	189.4	2532.1	1.99	1.48	0.15	26.7	22	16.5				19.8	0.8	220
	207.2	1320	0.00	2.25	0.00	0.00	73.3	2605.5	1.97	1.56	0.15	27.0	23	17						

*Indicates manual increase in Well Head Pressure

APPENDIX C
ANALYTICAL DATA REPORTS

Alpha Analytical. Inc.

255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

Boise, Idaho
(208) 336-4145

Las Vegas, Nevada
(702) 386-6747

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: AFSI-30B2001
Phone: (614) 424-6122
Attn: Eric Drescher

Alpha Analytical Number: BMI112294-01

Client I.D. Number: Fuel-WPAFB

Compound	Method	Concentration ug/Kg	Detection Limit ug/Kg	Date Analyzed
Benzene	8240	ND	40,000	11/28/94
Toluene	8240	90,000	40,000	11/28/94
Total Xylenes	8240	1,000,000	40,000	11/28/94
Ethylbenene	8240	180,000	40,000	11/28/94
C-range Compounds	**Method**	**Percentage of Total**	**Detection Limit (Not Applicable)**	**Date Analyzed**
C8 and <	GC/FID	0.32	NA	11/29/94
C9	GC/FID	0.92	NA	11/29/94
C10	GC/FID	3.25	NA	11/29/94
C11	GC/FID	5.14	NA	11/29/94
C12	GC/FID	7.03	NA	11/29/94
C13	GC/FID	10.14	NA	11/29/94
C14	GC/FID	11.64	NA	11/29/94
C15	GC/FID	11.54	NA	11/29/94
C16	GC/FID	11.86	NA	11/29/94
C17	GC/FID	10.25	NA	11/29/94
C18	GC/FID	8.34	NA	11/29/94
C19	GC/FID	6.36	NA	11/29/94
C20	GC/FID	5.29	NA	11/29/94
C21	GC/FID	3.00	NA	11/29/94
C22	GC/FID	2.14	NA	11/29/94
C23	GC/FID	1.16	NA	11/29/94
C24	GC/FID	0.72	NA	11/29/94
C25	GC/FID	0.32	NA	11/29/94
C26	GC/FID	0.19	NA	11/29/94
C27	GC/FID	0.11	NA	11/29/94
C28	GC/FID	0.09	NA	11/29/94
C29	GC/FID	0.04	NA	11/29/94
C30	GC/FID	0.04	NA	11/29/94
C31 and >	GC/FID	0.11	NA	11/29/94

Approved by: Roger L. Scholl
Roger L. Scholl, Ph.D.
Laboratory Director

Date: 11/30/94

Alpha Analytical, Inc.
255 Glendale Avenue. Suite 21
Sparks. Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

Boise. Idaho
(208) 336-4145

Las Vegas. Nevada
(702) 386-6747

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#:
Phone: (614) 424-6122
Attn: Jeff Kittel

Sampled: 10/25/94 Received: 10/27/94 Analyzed: 11/03-04/94

Matrix: [X] Soil [ ] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTXE - Benzene, Toluene, Xylenes, Ethylbenzene

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTXE - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
WPA-20.0-20.5' /BMI102794-01A	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
WPA-21.5-22.0' /BMI102794-02A	TPH (Purgeable)	1,800	200	mg/Kg
	Benzene	ND	400	ug/Kg
	Toluene	ND	400	ug/Kg
	Total Xylenes	ND	400	ug/Kg
	Ethylbenzene	ND	400	ug/Kg

ND - Not Detected

Approved by: Roger L. Scholl Date: 11/7/94
Roger L. Scholl, Ph.D.
Laboratory Director

Laboratory Analysis Report

Sierra Environmental Monitoring, Inc.

ALPHA ANALYTICAL
255 GLENDALE AVENUE, SUITE 21
SPARKS NV 89431

Date : 11/18/94
Client : ALP-855
Taken by: CLIENT
Report : 11603
PO# :

Page: 1

Sample	Collected Date	Time	ALKALINITY MG/L CACO3	PH S.U.	MOISTURE CONTENT %	KJELDAHL-N MG/L	PHOSPHORUS -TOTAL MG/L	IRON, TOTAL MG/L
MI102794-01A - WPA-20.0-20.5	10/25/94	:	14,121 mg/g	9.03	7.2	2.9 mg/g	<0.1 mg/kg	4,400mg/kg
MI102794-02A - WPA-21.5-22.0	10/25/94	:	11,804 mg/g	8.90	7.8	3.4 mg/g	<0.1 mg/kg	5,600mg/kg

Sample	Collected Date	Time	SIEVE ANALYSIS	DIGESTION-TOTAL METALS	DENSITY G/CM3	POROSITY %		
BMI102794-01A - WPA-20.0-20.5	10/25/94	:		YES				
MI102794-01B - WPA-19.5-21.0	10/25/94	:	YES		1.6	38.9		
MI102794-02A - WPA-21.5-22.0	10/25/94	:		YES				
MI102794-02B - WPA-21.0-22.5	10/25/94	:	YES		1.7	35.5		

proved By:

is report is applicable only to the sample received by the laboratory. The liability of the laboratory is limited to the amount paid for this report. This report is for the exclusive use of the client to whom it is addressed and upon the condition that the client assumes all liability for the further distribution of the report or its contents.

William F. Pillsbury
President

1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

John C. Sener
Manager

Sierra
Environmental
Monitoring, Inc.

November 18, 1994

TO: Alpha Analytical

FROM: Sierra Environmental Monitoring, Inc.

RE: Sieve Analysis - SEM 9410-708
BMI 102794-01B WPA-19.5-21.0

As per your request, we have performed sieve analysis testing on the sample submitted to this laboratory. Test results are as follows:

U.S. Standard Sieve Size	Cumulative Percent Passing
1 Inch	100
1/2 Inch	97
No. 4	85
No. 8	71
No. 10	67
No. 16	58
No. 30	38
No. 40	24
No. 50	17
No. 100	11
No. 200	7

We appreciate this opportunity to provide our laboratory testing services. If you have any questions or require further testing, please feel free to contact us at your convenience.

Sincerely,
SIERRA ENVIRONMENTAL MONITORING, INC.

Stephen Poole

Stephen Poole
Assistant Manager/ Senior Chemist

sieve2.alp

William F. Pillsbury
President

1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

John C. Sener
Manager

Sierra
Environmental
Monitoring, Inc.

November 18, 1994

TO: **Alpha Analytical**

FROM: Sierra Environmental Monitoring, Inc.

RE: Sieve Analysis - SEM 9410-710
BMI 102794-02B WPA-21.0-22.5

As per your request, we have performed sieve analysis testing on the sample submitted to this laboratory. Test results are as follows:

U.S. Standard Sieve Size	Cumulative Percent Passing
1 Inch	100
1/2 Inch	86
No. 4	65
No. 8	52
No. 10	48
No. 16	38
No. 30	25
No. 40	15
No. 50	11
No. 100	5
No. 200	< 1

We appreciate this opportunity to provide our laboratory testing services. If you have any questions or require further testing, please feel free to contact us at your convenience.

Sincerely,
SIERRA ENVIRONMENTAL MONITORING, INC.

Stephen Poole
Assistant Manager/ Senior Chemist

sieve2.alp

illiam F. Pillsbury
resident

1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

Jonn C. Sene
Manager

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

Boise, Idaho
(208) 336-4145

Las Vegas, Nevada
(702) 386-6747

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: 30B2001
Phone: (614) 424-6122
Attn: Al Pollack

Sampled: 10/28-29/94 Received: 11/03/94 Analyzed: 11/09-11/94

Matrix: [ ] Soil [X] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTXE - Benzene, Toluene, Xylenes, Ethylbenzene

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTXE - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit
GW-1-GW-3	TPH (Purgeable)	ND	0.50 mg/L
10/28/94	Benzene	ND	1.0 ug/L
(Composite)	Toluene	ND	1.0 ug/L
/BMI110394-01	Total Xylenes	ND	1.0 ug/L
	Ethylbenzene	ND	1.0 ug/L
GW-1-GW-3	TPH (Purgeable)	ND	0.50 mg/L
10/29/94	Benzene	ND	1.0 ug/L
(Composite)	Toluene	ND	1.0 ug/L
/BMI110394-02	Total Xylenes	ND	1.0 ug/L
	Ethylbenzene	ND	1.0 ug/L

ND - Not Detected

Approved by: Roger L. Scholl Date: 11/15/94
Roger L. Scholl, Ph.D.
Laboratory Director

AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

[illegible] BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-1020

№ 002329

CHAIN-OF-CUSTODY RECORD

Contact Person MR. AL POLLACK
Company BATTELLE MEMORIAL INSTITUTE
Address 505 KING AVE City COLUMBUS State OH Zip 43201
Phone (614) 424-3753 FAX (614) 424-3667

Project Info:
P.O. #
Project # 30B2001
Project Name BIOSLURPER

Turn Around Time:
☒ Normal
☐ Rush ______ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
	WP-BIOSLURPER (PL-2) - #1	10/29/94 @ 1480	BTEX/TPH ~~referenced~~ as JET FUEL (MODIFIED EPA TO-3)	30" Hg	ATM	
	WP-BIOSLURPER (PL-2) - #2	10/31/94	BTEX/TPH as JET FUEL (MODIFIED EPA TO-3)	18.5" Hg	ATM	

Collected By: Print M. PLACE / E. DRESCHER
Signature

Relinquished By: (Signature) Date/Time Al Pollack 11/2/94 0900 hrs
Received By: (Signature) Date/Time
Time

Relinquished By: (Signature) Date/Time
Received By: (Signature) Date/Time
Time

Relinquished By: (Signature) Date/Time
Received By: (Signature) Date/Time

Notes: GRAB SAMPLES OF STACK GAS OFF OF THE BIOSLURPER.

Lab Use Only	Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact? Yes No None	Work Order #

Form 1293 rev 05

AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9411023

Work Order Summary

CLIENT: Mr. Al Pollack
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

BILL TO: Same

PHONE: 614-424-3753
FAX: 614-424-3667
DATE RECEIVED: 11/3/94
DATE COMPLETED: 12/2/94

INVOICE # 5362
P.O. # 91221
PROJECT # 30B2001 BIOSLURPER
AMOUNT$: $270.00

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.	PRICE
01A	WP-BIOSLURPER (P6-2)-#1	TO-3	1.0 "Hg	$125.00
02A	WP-BIOSLURPER (P6-2)-#2	TO-3	0.5 "Hg	$125.00
03A	Lab Blank	TO-3	NA	NC

Misc. Charges 1 Liter SUMMA Canister Preparation (2) @ $10.00 each. $20.00

CERTIFIED BY: [signature]
Laboratory Director

DATE: 12/2/94

180 BLUE RAVINE ROAD. SUITE B • FOLSOM, CA 95630
(916) 985-1000 • FAX (916) 985-1020

AIR TOXICS LTD.

SAMPLE NAME: WP-BIOSLURPER (P6-2)-#1
ID#: 9411023-01A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6111113 — Date of Collection: 10/29/94
Dil. Factor: 16 — Date of Analysis: 11/11/94

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.016	0.052	Not Detected	Not Detected
Toluene	0.016	0.061	Not Detected	Not Detected
Ethyl Benzene	0.016	0.071	1.2	5.3
Total Xylenes	0.016	0.071	4.1	18

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6111113 — Date of Collection: 10/29/94
Dil. Factor: 16 — Date of Analysis: 11/11/94

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.16	1.0	220	1400

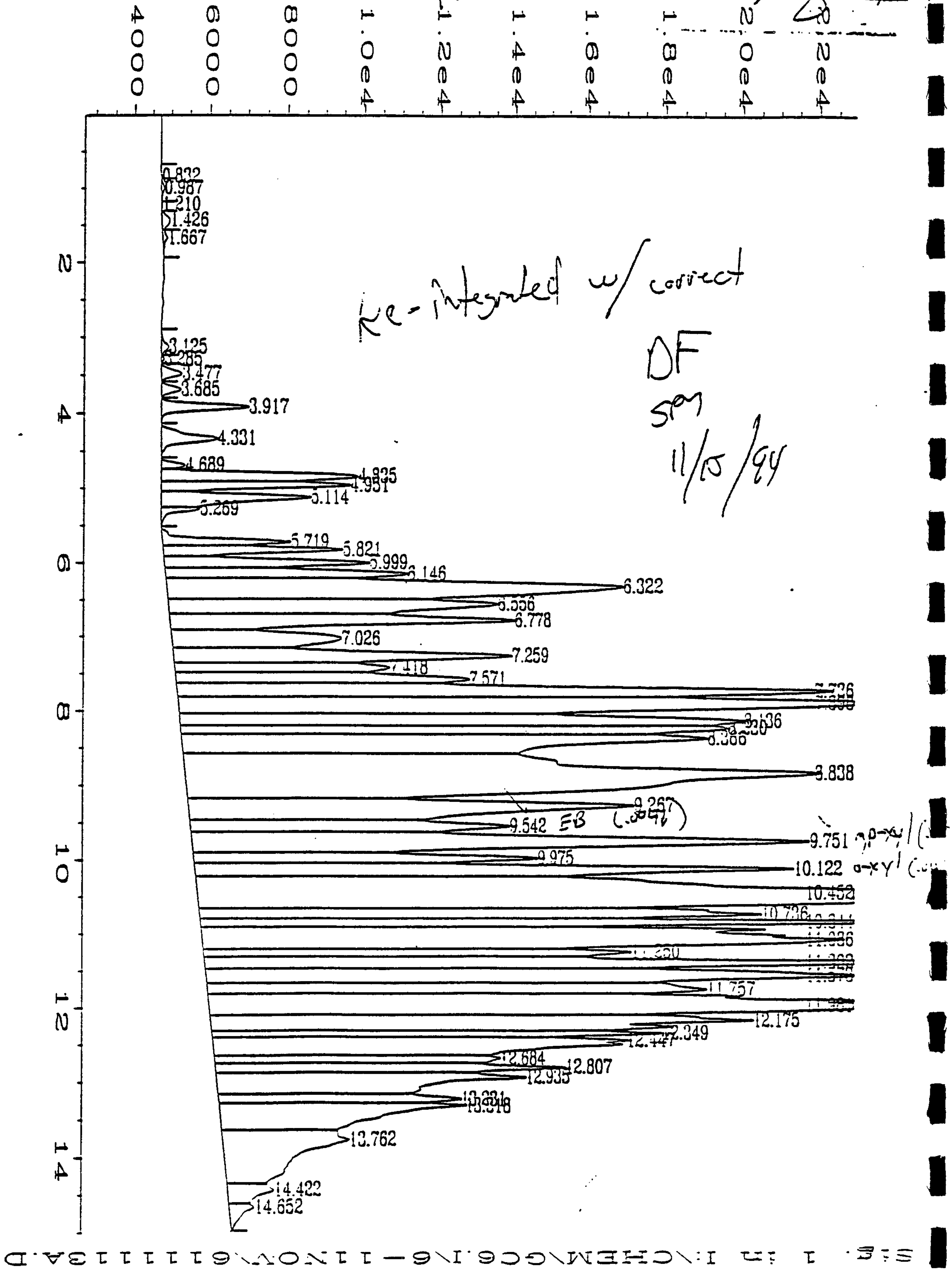
*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

11023-01A

Re-integrated w/ correct DF

SPM 11/15/94



External Standard Report

Data File Name	: I:\CHEM\GC6.I\6-11NOV\6111113A.D		
Operator	: SPM	Page Number	: 1
Instrument	: GC_6	Vial Number	:
Sample Name	: 9411023-01A	Injection Number	:
Run Time Bar Code:		Sequence Line	:
Acquired on	: 11 Nov 94 02:27 PM	Instrument Method:	BTEX1109.MTH
Report Created on:	15 Nov 94 11:50 AM	Analysis Method	: BTEX1109.MTH
Last Recalib on	: 06 AUG 94 10:19 AM	Sample Amount	: 0
Multiplier	: 15.83	ISTD Amount	:

Sig. 1 in I:\CHEM\GC6.I\6-11NOV\6111113A.D

SPM 11/15/94

Ret Time	Area	Type	Width	Ref#	ppmv	Name
3.685	3036	VV	0.093	1	0.116	MTBE
5.114	28494	VV	0.109	1	0.487	BENZENE ND
6.778	78294	VV	0.127	1	1.252	TOLUENE N.D.
9.542	68904	VV	0.118	1	1.167	ETH.BNZ.
9.751	175934	VV	0.166	1	2.061	M,P-XYLENE
10.122	128566	VV	0.117	1	1.990	O-XYLENE
0.832	28	BV	0.023		436.865	* uncalibrated *
0.987	766	VV	0.115		12117.96	* uncalibrated *
1.210	85	VV	0.057		1351.424	* uncalibrated *
1.426	2118	PV	0.132		33526.09	* uncalibrated *
1.667	1120	VB	0.116		17727.64	* uncalibrated *
3.125	1482	BV	0.111		23463.06	* uncalibrated *
3.285	280	VV	0.056		4440.035	* uncalibrated *
3.477	3449	VV	0.095		54593.21	* uncalibrated *
3.917	13073	VV	0.092		206953.0	* uncalibrated *
4.331	11747	VV	0.121		185961.5	* uncalibrated *
4.689	2884	VV	0.071		45648.91	* uncalibrated *
4.835	34672	VV	0.110		548851.7	* uncalibrated *
4.951	27762	VV	0.086		439469.1	* uncalibrated *
5.269	4608	VV	0.067		72942.69	* uncalibrated *
5.719	17322	PV	0.081		274207.6	* uncalibrated *
5.821	26674	VV	0.088		422252.7	* uncalibrated *
5.999	34464	VV	0.100		545568.5	* uncalibrated *
6.146	44038	VV	0.109		697116.9	* uncalibrated *
6.322	155719	VV	0.181		2465034.	* uncalibrated *
6.556	89317	VV	0.146		1413889.	* uncalibrated *
7.026	53548	VV	0.188		847662.1	* uncalibrated *
7.259	75516	VV	0.129		1195424.	* uncalibrated *
7.418	38357	VV	0.102		607189.3	* uncalibrated *
7.571	58076	VV	0.111		919348.1	* uncalibrated *
7.736	145556	VV	0.128		2304156.	* uncalibrated *
7.898	204635	VV	0.170		3239371.	* uncalibrated *
8.136	125945	VV	0.125		1993717.	* uncalibrated *
8.230	94011	VV	0.109		1488198.	* uncalibrated *
8.366	172451	VV	0.169		2729899.	* uncalibrated *
8.838	410514	VV	0.320		6498432.	* uncalibrated *
9.267	148280	VV	0.175		2347268.	* uncalibrated *
9.975	62709	VV	0.103		992689.6	* uncalibrated *
10.452	413135	VV	0.214		6539927.	* uncalibrated *
10.736	109771	VV	0.100		1737678.	* uncalibrated *
10.844	106442	VV	0.076		1684976.	* uncalibrated *
11.086	250154	VV	0.204		3959933.	* uncalibrated *
11.250	67781	VV	0.085		1072970.	* uncalibrated *
11.392	147749	VV	0.090		2338863.	* uncalibrated *
11.573	166754	VV	0.124		2639722.	* uncalibrated *

Total xylenes: ~~4.05~~ 4.1 ppmv

11.757	110793	VV	0.117	1753852.	* uncalibrated *
11.981	292337	VV	0.128	4627693.	* uncalibrated *
12.175	157688	VV	0.143	2496199.	* uncalibrated *
12.349	55484	VV	0.067	878311.4	* uncalibrated *
12.447	135067	VV	0.175	2138107.	* uncalibrated *
12.684	45650	VV	0.102	722633.8	* uncalibrated *
12.807	59226	VV	0.089	937553.4	* uncalibrated *
12.935	103576	VV	0.165	1639612.	* uncalibrated *
13.231	40862	VV	0.092	646849.0	* uncalibrated *
13.318	93199	VV	0.183	1475341.	* uncalibrated *
13.762	85895	VV	0.323	1359721.	* uncalibrated *
14.422	13848	VV	0.157	219208.7	* uncalibrated *
14.652	6345	VBA	0.134	100445.4	* uncalibrated *

==

External Standard Report

Data File Name : I:\CHEM\GC6.I\6-11NOV\6111113A.D
Operator : SPM
Instrument : GC_6
Sample Name : 9411023-01A
Run Time Bar Code:
Acquired on : 11 Nov 94 02:27 PM
Report Created on: 11 Nov 94 02:42 PM
Last Recalib on : 06 AUG 94 10:19 AM
Multiplier : ~~3.48~~ 5.83
Sample Info : 33ML CAN#9452 BATT MEM BTEX 1"TO15PSI TPHGAS

Page Number : 1
Vial Number :
Injection Number :
Sequence Line :
Instrument Method: BTEX1109.MTH
Analysis Method : BTEX1109.MTH
Sample Amount : 0
ISTD Amount :

Sig. 1 in I:\CHEM\GC6.I\6-11NOV\6111113A.D

Ret Time	Area	Type	Width	Ref#	ppmv	Name
3.685	3036	VV	0.093	1	0.0256	MTBE
5.114	28494	VV	0.109	1	0.107	BENZENE
6.778	78294	VV	0.127	1	0.275	TOLUENE
9.542	68904	VV	0.118	1	0.257	ETH.BNZ.
9.751	175934	VV	0.166	1	0.453	M,P-XYLENE Total xylenes:
10.122	128566	VV	0.117	1	0.438	O-XYLENE
0.832	28	BV	0.023		96.038	* uncalibrated *
0.987	766	VV	0.115		2663.961	* uncalibrated *
1.210	85	VV	0.057		297.091	* uncalibrated *
1.426	2118	PV	0.132		7370.234	* uncalibrated *
1.667	1120	VB	0.116		3897.169	* uncalibrated *
3.125	1482	BV	0.111		5158.020	* uncalibrated *
3.285	280	VV	0.056		976.079	* uncalibrated *
3.477	3449	VV	0.095		12001.54	* uncalibrated *
3.917	13073	VV	0.092		45495.67	* uncalibrated *
4.331	11747	VV	0.121		40881.00	* uncalibrated *
4.689	2884	VV	0.071		10035.26	* uncalibrated *
4.835	34672	VV	0.110		120657.2	* uncalibrated *
4.951	27762	VV	0.086		96611.01	* uncalibrated *
5.269	4608	VV	0.067		16035.41	* uncalibrated *
5.719	17322	PV	0.081		60280.64	* uncalibrated *
5.821	26674	VV	0.088		92826.25	* uncalibrated *
5.999	34464	VV	0.100		119935.5	* uncalibrated *
6.146	44038	VV	0.109		153251.2	* uncalibrated *
6.322	155719	VV	0.181		541902.5	* uncalibrated *
6.556	89317	VV	0.146		310823.3	* uncalibrated *
7.026	53548	VV	0.188		186346.4	* uncalibrated *
7.259	75516	VV	0.129		262797.0	* uncalibrated *
7.418	38357	VV	0.102		133481.9	* uncalibrated *
7.571	58076	VV	0.111		202105.6	* uncalibrated *
7.736	145556	VV	0.128		506535.9	* uncalibrated *
7.898	204635	VV	0.170		712129.6	* uncalibrated *
8.136	125945	VV	0.125		438290.3	* uncalibrated *
8.230	94011	VV	0.109		327159.1	* uncalibrated *
8.366	172451	VV	0.169		600129.4	* uncalibrated *
8.838	410514	VV	0.320		1428588.	* uncalibrated *
9.267	148280	VV	0.175		516013.4	* uncalibrated *
9.975	62709	VV	0.103		218228.7	* uncalibrated *
10.452	413135	VV	0.214		1437710.	* uncalibrated *
10.736	109771	VV	0.100		382003.8	* uncalibrated *
10.844	106442	VV	0.076		370418.0	* uncalibrated *
11.086	250154	VV	0.204		870534.8	* uncalibrated *
11.250	67781	VV	0.085		235877.2	* uncalibrated *
11.392	147749	VV	0.090		514165.7	* uncalibrated *

11.573	166754	VV	0.124	580305.3	* uncalibrated *
11.757	110793	VV	0.117	385559.3	* uncalibrated *
11.981	292337	VV	0.128	1017332.	* uncalibrated *
12.175	157688	VV	0.143	548753.8	* uncalibrated *
12.349	55484	VV	0.067	193084.3	* uncalibrated *
12.447	135067	VV	0.175	470032.3	* uncalibrated *
12.684	45650	VV	0.102	158860.7	* uncalibrated *
12.807	59226	VV	0.089	206107.8	* uncalibrated *
12.935	103576	VV	0.165	360445.3	* uncalibrated *
13.231	40862	VV	0.092	142200.5	* uncalibrated *
13.318	93199	VV	0.183	324332.7	* uncalibrated *
13.762	85895	VV	0.323	298915.2	* uncalibrated *
14.422	13848	VV	0.157	48189.91	* uncalibrated *
14.652	6345	VBA	0.134	22081.49	* uncalibrated *

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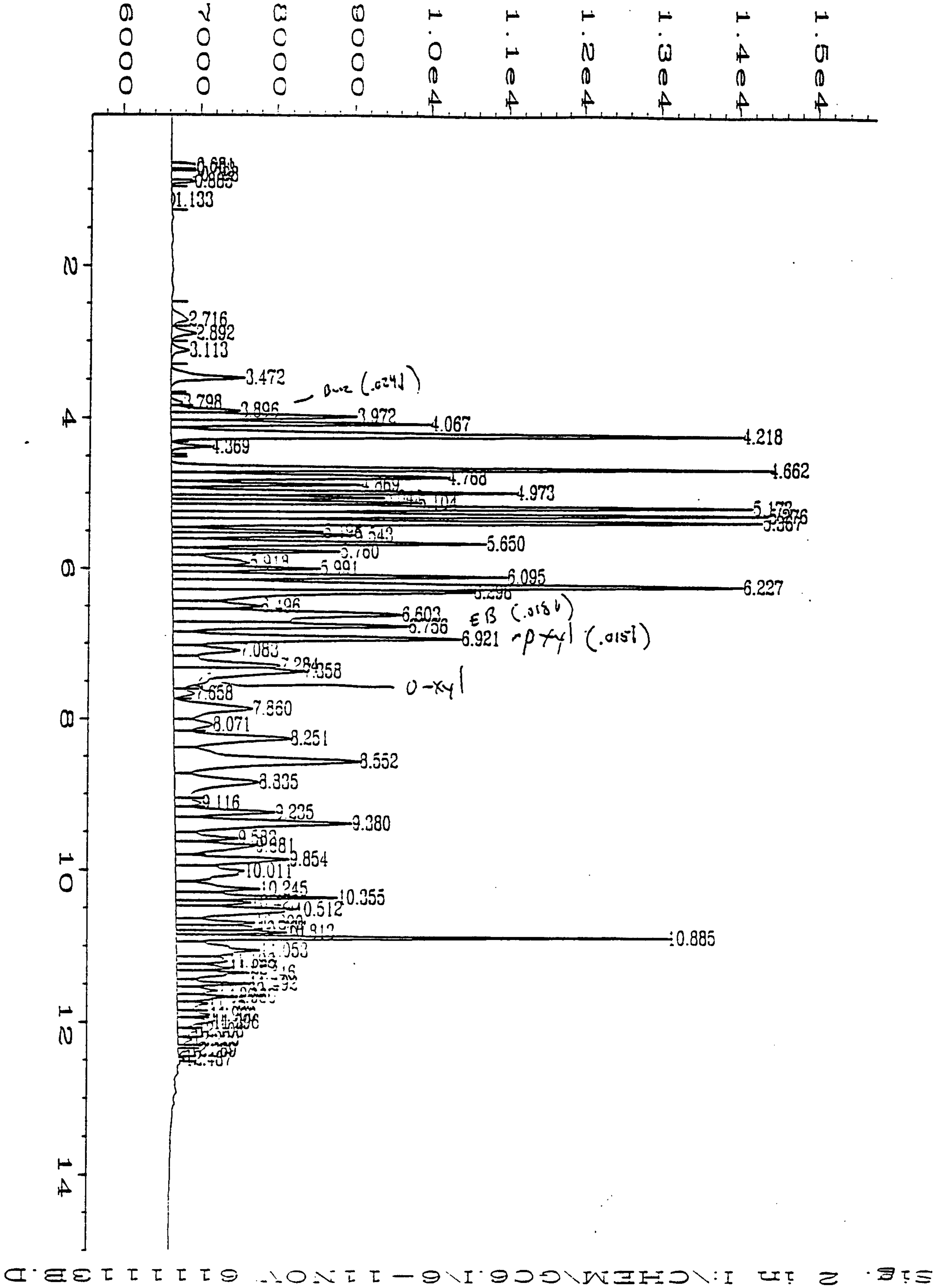
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3.972
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8.835
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9.235
9.380
9.854
10.011
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10.355
10.512
10.885
Benz (.0241)
EB (.0186)
m p xyl (.0151)
o-xyl

Area Percent Report

Data File Name : I:\CHEM\GC6.I\6-11NOV\6111113B.D
Operator : SPM
Instrument : GC_6
Sample Name : 9411023-01A
Run Time Bar Code:
Acquired on : 11 Nov 94 02:27 PM
Report Created on: 11 Nov 94 02:43 PM SPM 11/15/94
Multiplier : ~~3.18~~ 15.87
Sample Info : 33ML CAN#9452 BATT MEM BTEX 1"TO15PSI TPHGAS

Page Number : 1
Vial Number :
Injection Number :
Sequence Line :
Instrument Method: BTEX1109.MTH
Analysis Method : TPH .MTH

Sig. 2 in I:\CHEM\GC6.I\6-11NOV\6111113B.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	0.681	1236	321	BV	0.056	0.7293
2	0.733	512	322	VV	0.026	0.3022
3	0.798	2268	376	VV	0.080	1.3376
4	0.885	753	294	VV	0.039	0.4440
5	1.133	320	37	PV	0.117	0.1890
6	2.716	1481	218	BV	0.091	0.8737
7	2.892	1458	318	VV	0.068	0.8598
8	3.113	1006	231	VV	0.062	0.5934
9	3.472	4114	972	VB	0.061	2.4268
10	3.798	537	160	BV	0.050	0.3165
11	3.896	2706	904	VV	0.044	1.5963
12	3.972	9025	2413	VV	0.058	5.3233
13	4.067	9888	3368	VV	0.044	5.8322
14	4.218	27992	7422	VV	0.056	16.5104
15	4.369	1400	523	VB	0.040	0.8258
16	4.662	21347	7835	BV	0.042	12.5911
17	4.768	13885	3577	VV	0.062	8.1898
18	4.869	6162	2455	VV	0.039	3.6344
19	4.973	13100	4461	VV	0.046	7.7267
20	5.042	6989	2771	VV	0.038	4.1220
21	5.104	8507	3198	VV	0.040	5.0176
22	5.173	26291	7533	VV	0.053	15.5070
23	5.276	24804	7737	VV	0.048	14.6299
24	5.367	26975	7653	VV	0.056	15.9103
25	5.496	5327	1957	VV	0.041	3.1418
26	5.543	7611	2362	VV	0.049	4.4892
27	5.650	13958	4062	VV	0.052	8.2330
28	5.760	6719	2172	VV	0.048	3.9628
29	5.918	5993	1009	VV	0.078	3.5346
30	5.991	6784	1915	VV	0.054	4.0016
31	6.095	14681	4335	VV	0.051	8.6591
32	6.227	33157	7392	VV	0.066	19.5566
33	6.298	18066	3887	VV	0.065	10.6556
34	6.496	5514	1146	VV	0.068	3.2521
35	6.603	20161	2963	VV	0.099	11.8914
36	6.756	12992	3053	VV	0.063	7.6633
37	6.921	17112	3721	VV	0.070	10.0930
38	7.083	4715	868	VV	0.080	2.7810
39	7.284	7679	1383	VV	0.082	4.5294
40	7.358	12970	1675	VV	0.098	7.6499
41	7.658	1315	273	VV	0.074	0.7756
42	7.860	8042	1030	VV	0.110	4.7434
43	8.071	3425	501	VV	0.102	2.0204
44	8.251	10226	1502	VV	0.100	6.0313
45	8.552	19918	2393	VV	0.118	11.7483

46	8.835	10013	1096	VV	0.130	5.9060
47	9.116	1734	340	VV	0.075	1.0228
48	9.235	5906	1295	VV	0.070	3.4833
49	9.380	13722	2280	VV	0.090	8.0935
50	9.583	3555	815	VV	0.062	2.0971
51	9.681	6545	1040	VV	0.087	3.8605
52	9.854	7682	1467	VV	0.073	4.5309
53	10.011	7620	893	VV	0.108	4.4943
54	10.245	5139	1093	VV	0.064	3.0308
55	10.355	7043	2095	VV	0.049	4.1542
56	10.423	3334	975	VV	0.052	1.9665
57	10.512	9638	1529	VV	0.087	5.6848
58	10.690	3648	1023	VV	0.052	2.1515
59	10.767	3849	1063	VV	0.048	2.2702
60	10.813	3899	1430	VV	0.040	2.2995
61	10.885	14000	6437	VV	0.034	8.2578
62	11.053	7826	1082	VV	0.093	4.6159
63	11.198	3436	663	VV	0.069	2.0268
64	11.287	2538	684	VV	0.052	1.4970
65	11.346	3830	919	VV	0.061	2.2591
66	11.492	2856	942	VV	0.044	1.6844
67	11.583	2227	526	VV	0.057	1.3138
68	11.660	2600	663	VV	0.054	1.5333
69	11.753	1826	394	VV	0.061	1.0768
70	11.900	1658	417	VV	0.055	0.9777
71	11.996	2263	455	VV	0.065	1.3349
72	12.108	1174	250	VV	0.066	0.6922
73	12.230	759	182	VV	0.060	0.4476
74	12.369	424	145	VV	0.042	0.2503
75	12.487	143	78	PV	0.030	0.0841

Total TPH area = (590005 - 1200)(15.83)/4301826 = 220 ppmV SPM 11/15/9

==

AIR TOXICS LTD.

SAMPLE NAME: WP-BIOSLURPER (P6-2)-#2
ID#: 9411023-02A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6111114 Date of Collection: 10/31/94
Dil. Factor: 100 Date of Analysis: 11/11/94

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.10	0.32	Not Detected	Not Detected
Toluene	0.10	0.38	Not Detected	Not Detected
Ethyl Benzene	0.10	0.44	6.4	28
Total Xylenes	0.10	0.44	20	88

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6111114 Date of Collection: 10/31/94
Dil. Factor: 100 Date of Analysis: 11/11/94

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	1.0	6.5	970	6300

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: WP-BIOSLURPER (P6-2)-#2
ID#: 9411023-02A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6111114		Date of Collection: 10/31/94	
Dil. Factor:	100		Date of Analysis: 11/11/94	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.10	0.32	Not Detected	Not Detected
Toluene	0.10	0.38	Not Detected	Not Detected
Ethyl Benzene	0.10	0.44	6.4	28
Total Xylenes	0.10	0.44	20	88

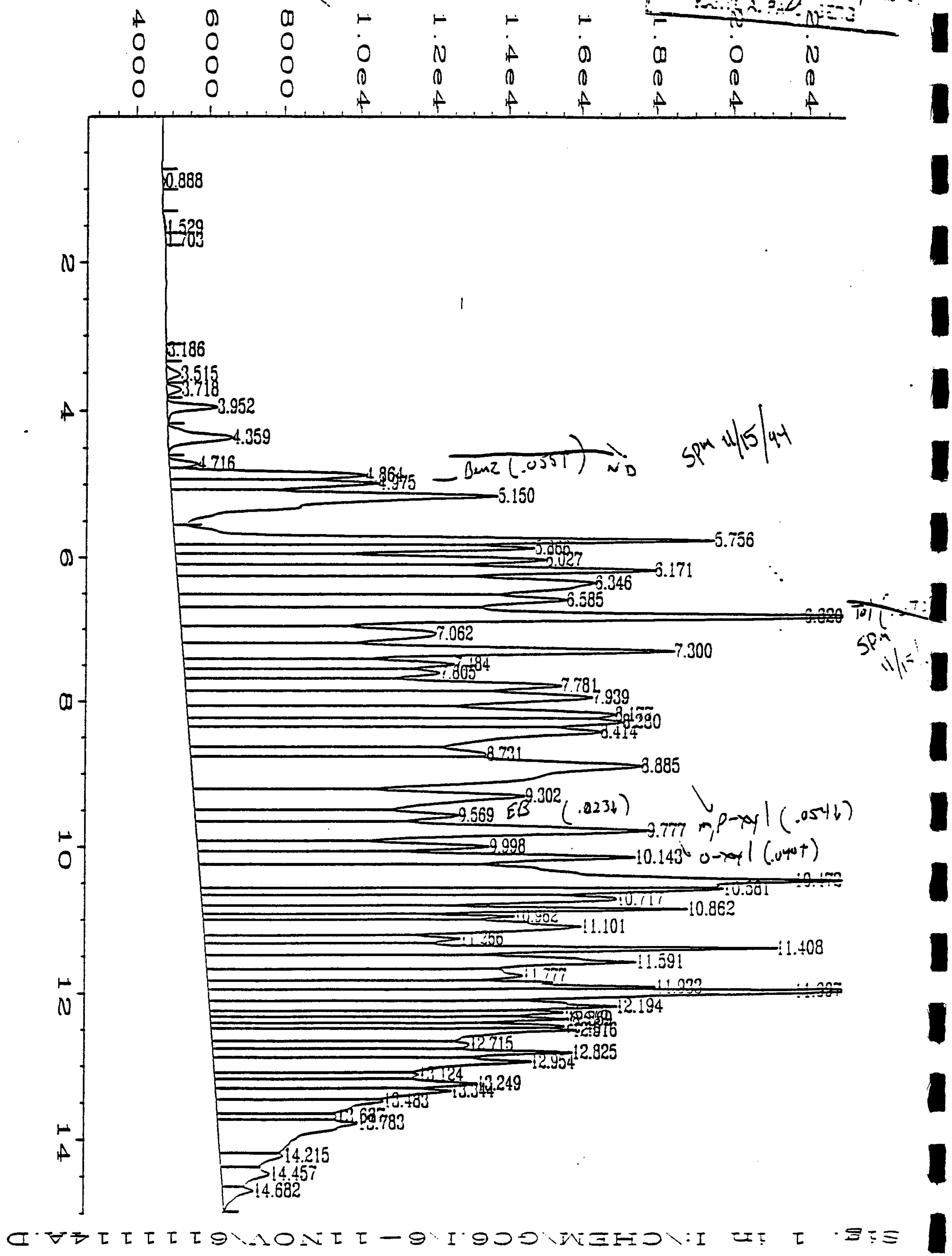
TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6111114		Date of Collection: 10/31/94	
Dil. Factor:	100		Date of Analysis: 11/11/94	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH*	1.0	6.5	970	6300

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

11023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10
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13.483
13.783
14.215
14.457
14.682
Benz (.0551) ND
SPM 11/15/94
EB (.0234)
m,p-xyl (.0546)
o-xyl (.0404)
Sig. 1 in I:\CHEM\GC6.1\6-11NOV\611114A.D

External Standard Report

ata File Name : I:\CHEM\GC6.I\6-11NOV\6111114A.D
perator : SPM
Instrument : GC_6
ample Name : 9411023-02A
un Time Bar Code:
Acquired on : 11 Nov 94 02:54 PM
eport Created on: 11 Nov 94 03:09 PM
ast Recalib on : 06 AUG 94 10:19 AM
ultiplier : 102.5
Sample Info : 5ML CAN#12283 BATTELLE BTEX 0.5"TO15PSI TPHGAS

Page Number : 1
Vial Number :
Injection Number :
Sequence Line :
Instrument Method: BTEX1109.MTH
Analysis Method : BTEX1109.MTH
Sample Amount : 0
ISTD Amount :

ig. 1 in I:\CHEM\GC6.I\6-11NOV\6111114A.D

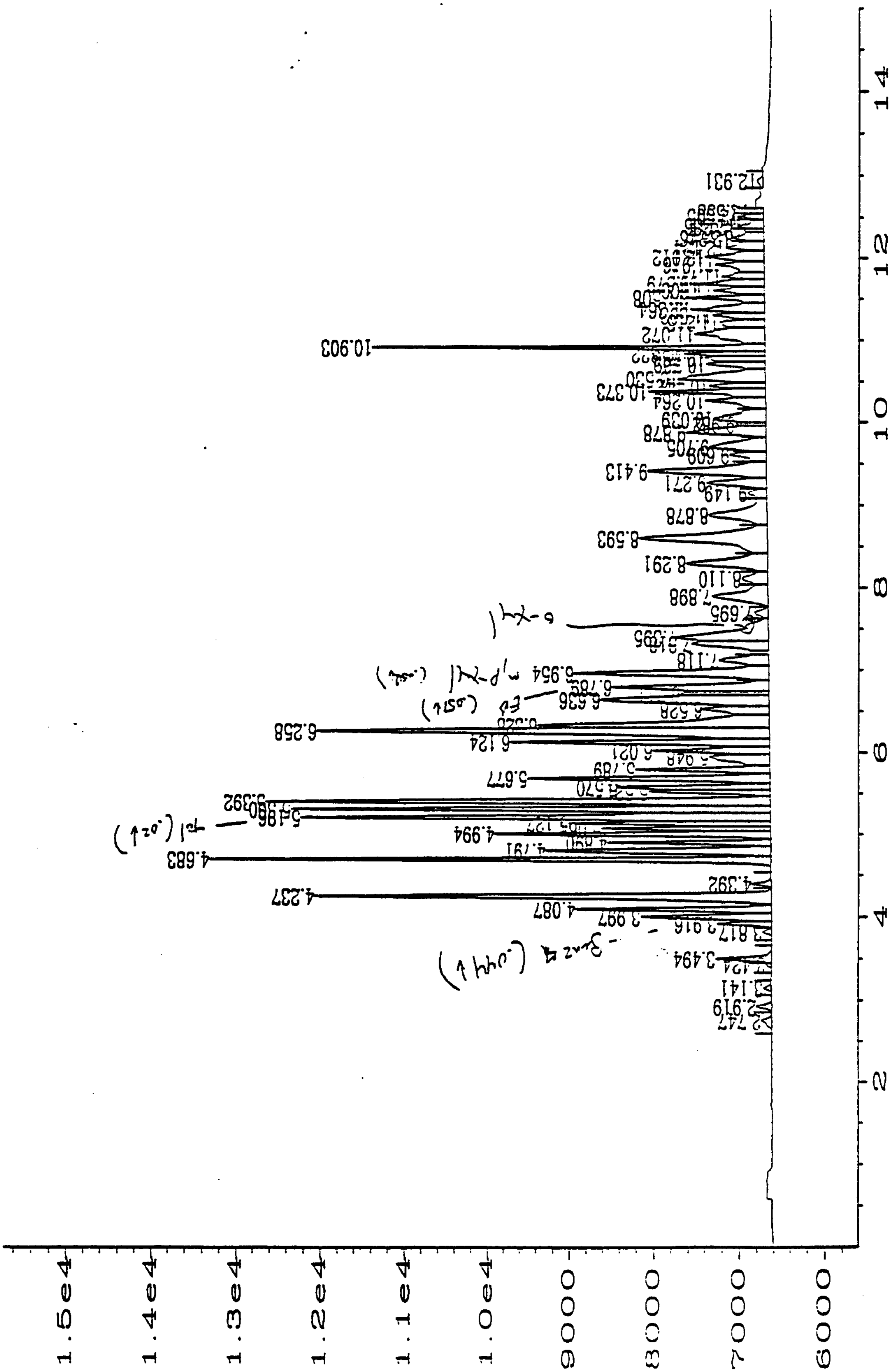
SPM 11/15/94

Ret Time	Area	Type	Width	Ref#	ppmv	Name
3.718	2102	VV	0.085	1	0.521	MTBE
4.975	37069	VV	0.102	1	~~4.104~~	~~BENZENE~~ ND.
6.820	172958	VV	0.134	1	~~17.905~~	~~TOLUENE~~ ND.
9.569	58149	VV	0.119	1	6.377	ETH.BNZ.
9.777	135269	VV	0.160	1	10.260	M,P-XYLENE Total xylenes: 20 ppmv
10.143	94666	VV	0.114	1	9.490	O-XYLENE
0.888	417	BV	0.070		42770.47	* uncalibrated *
1.529	510	BV	0.131		52255.80	* uncalibrated *
1.703	150	VB	0.110		15378.61	* uncalibrated *
3.186	223	VB	0.082		22876.78	* uncalibrated *
3.515	2395	BV	0.094		245513.6	* uncalibrated *
3.952	7471	VV	0.088		765735.5	* uncalibrated *
4.359	14188	VV	0.127		1454311.	* uncalibrated *
4.716	3693	PV	0.075		378552.7	* uncalibrated *
4.864	33032	VV	0.102		3385768.	* uncalibrated *
5.150	96948	VV	0.151		9937149.	* uncalibrated *
5.756	89258	VV	0.091		9148901.	* uncalibrated *
5.866	58022	VV	0.090		5947215.	* uncalibrated *
6.027	73457	VV	0.114		7529320.	* uncalibrated *
6.171	98141	VV	0.112		1.0E+007	* uncalibrated *
6.346	152138	VV	0.181		1.6E+007	* uncalibrated *
6.585	99212	VV	0.134		1.0E+007	* uncalibrated *
7.062	82300	VV	0.187		8435780.	* uncalibrated *
7.300	112649	VV	0.128		1.2E+007	* uncalibrated *
7.484	53031	VV	0.108		5435694.	* uncalibrated *
7.605	49795	VV	0.108		5104007.	* uncalibrated *
7.781	86688	VV	0.128		8885550.	* uncalibrated *
7.939	118078	VV	0.164		1.2E+007	* uncalibrated *
8.177	97169	VV	0.126		9959852.	* uncalibrated *
8.280	83419	VV	0.100		8550467.	* uncalibrated *
8.414	147615	VV	0.177		1.5E+007	* uncalibrated *
8.731	57912	VV	0.123		5935961.	* uncalibrated *
8.885	242799	VV	0.265		2.5E+007	* uncalibrated *
9.302	117000	VV	0.181		1.2E+007	* uncalibrated *
9.998	54631	VV	0.105		5599702.	* uncalibrated *
10.472	228897	VV	0.168		2.3E+007	* uncalibrated *
10.581	74932	VV	0.090		7680502.	* uncalibrated *
10.717	84121	VV	0.117		8622409.	* uncalibrated *
10.862	65064	VV	0.073		6669103.	* uncalibrated *
10.962	34752	VV	0.070		3562052.	* uncalibrated *
11.101	108272	VV	0.134		1.1E+007	* uncalibrated *
11.266	40819	VV	0.084		4183911.	* uncalibrated *
11.408	94456	VV	0.086		9681719.	* uncalibrated *
11.591	107745	VV	0.120		1.1E+007	* uncalibrated *

11.777	73649	VV	0.119	7549015.	* uncalibrated *
11.933	70126	VV	0.097	7187925.	* uncalibrated *
11.997	133333	VV	0.083	1.4E+007	* uncalibrated *
12.194	77458	VV	0.095	7939396.	* uncalibrated *
12.278	45133	VV	0.067	4626170.	* uncalibrated *
12.369	43228	VV	0.064	4430898.	* uncalibrated *
12.467	39678	VV	0.069	4067035.	* uncalibrated *
12.516	79610	VV	0.137	8159980.	* uncalibrated *
12.715	42490	VV	0.092	4355224.	* uncalibrated *
12.825	57949	VV	0.082	5939722.	* uncalibrated *
12.954	81154	VV	0.126	8318270.	* uncalibrated *
13.124	27014	VV	0.069	2768904.	* uncalibrated *
13.249	46774	VV	0.096	4794369.	* uncalibrated *
13.344	47964	VV	0.101	4916285.	* uncalibrated *
13.483	42255	VV	0.125	4331136.	* uncalibrated *
13.687	14633	VV	0.067	1499920.	* uncalibrated *
13.783	65206	VV	0.222	6683645.	* uncalibrated *
14.215	15001	VV	0.122	1537610.	* uncalibrated *
14.457	15061	VV	0.158	1543793.	* uncalibrated *
14.682	7008	VBA	0.116	718280.6	* uncalibrated *

===

Sig. 2 in I:\CHEM\GC6.I\6-11NOV\6111114B.D



Area Percent Report

Data File Name : I:\CHEM\GC6.I\6-11NOV\6111114B.D
Operator : SPM
Page Number : 1
Instrument : GC_6
Vial Number :
Sample Name : 9411023-02A
Injection Number :
Run Time Bar Code:
Sequence Line :
Acquired on : 11 Nov 94 02:54 PM
Instrument Method: BTEX1109.MTH
Report Created on: 11 Nov 94 03:10 PM
Analysis Method : TPH .MTH
Multiplier : 102.5
Sample Info : 5ML CAN#12283 BATTELLE BTEX 0.5"TO15PSI TPHGAS

Sig. 2 in I:\CHEM\GC6.I\6-11NOV\6111114B.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	2.747	599	123	BV	0.068	15.0640
2	2.919	589	183	VB	0.049	14.8223
3	3.141	278	96	BB	0.045	6.9949
4	3.424	167	68	BV	0.038	4.1941
5	3.494	2003	652	VB	0.047	50.3757
6	3.817	319	112	BV	0.044	8.0231
7	3.916	1604	640	VV	0.039	40.3450
8	3.997	4987	1527	VV	0.052	125.3929
9	4.087	6201	2310	VV	0.041	155.9351
10	4.237	18893	5451	VV	0.052	475.0848
11	4.392	613	226	VV	0.041	15.4020
12	4.683	16492	6693	VV	0.038	414.7090
13	4.791	10133	2649	VV	0.061	254.7915
14	4.890	4538	1912	VV	0.037	114.1027
15	4.994	9211	3280	VV	0.044	231.6204
16	5.064	4895	1988	VV	0.038	123.0999
17	5.127	6282	2382	VV	0.039	157.9635
18	5.196	19283	5600	VV	0.052	484.8861
19	5.300	17547	5711	VV	0.047	441.2428
20	5.392	20332	6013	VV	0.054	511.2579
21	5.521	3891	1420	VV	0.042	97.8543
22	5.570	5659	1779	VV	0.047	142.2891
23	5.677	9549	2866	VV	0.050	240.1140
24	5.789	4851	1577	VV	0.047	121.9893
25	5.948	4253	708	VV	0.079	106.9328
26	6.021	4732	1359	VV	0.051	118.9825
27	6.124	10009	3071	VV	0.049	251.6795
28	6.258	23773	5402	VV	0.066	597.8029
29	6.328	12485	2735	VV	0.064	313.9423
30	6.528	3744	777	VV	0.068	94.1493
31	6.636	10806	1972	VV	0.083	271.7306
32	6.711	2713	1034	VV	0.038	68.2101
33	6.789	7586	1830	VV	0.062	190.7574
34	6.954	10632	2293	VV	0.067	267.3453
35	7.118	3048	569	VV	0.080	76.6366
36	7.318	4427	895	VV	0.074	111.3086
37	7.395	8014	1069	VV	0.101	201.5102
38	7.695	749	165	VV	0.072	18.8409
39	7.898	4996	647	VV	0.109	125.6385
40	8.110	1986	302	VV	0.097	49.9488
41	8.291	6175	945	VV	0.097	155.2879
42	8.593	12184	1487	VV	0.118	306.3647
43	8.878	5963	674	VV	0.125	149.9423
44	9.149	1096	221	VV	0.072	27.5494
45	9.271	3292	638	VV	0.074	82.7904

46	9.413	8014	1380	VV	0.088	201.5207
47	9.609	2010	420	VV	0.068	50.5341
48	9.705	4043	663	VV	0.085	101.6605
49	9.878	4741	928	VV	0.072	119.2124
50	9.982	781	351	VV	0.037	19.6441
51	10.039	3961	606	VV	0.086	99.6070
52	10.264	3257	703	VV	0.063	81.9083
53	10.373	4486	1369	VV	0.047	112.8029
54	10.442	2166	654	VV	0.049	54.4750
55	10.530	6256	1005	VV	0.085	157.3125
56	10.709	2526	686	VV	0.054	63.5217
57	10.786	2504	698	VV	0.060	62.9611
58	10.832	2585	948	VV	0.040	65.0009
59	10.903	10107	4689	VV	0.034	254.1485
60	11.072	6116	818	VV	0.097	153.8042
61	11.215	2641	520	VV	0.068	66.4165
62	11.303	2192	606	VV	0.050	55.1119
63	11.364	3669	848	VV	0.063	92.2624
64	11.508	2820	923	VV	0.045	70.9113
65	11.600	2395	589	VV	0.055	60.2238
66	11.679	2993	752	VV	0.055	75.2537
67	11.771	1931	490	VV	0.053	48.5630
68	11.916	2942	569	VV	0.069	73.9871
69	12.012	3417	685	VV	0.066	85.9221
70	12.124	2233	439	VV	0.070	56.1448
71	12.246	1757	364	VV	0.067	44.1854
72	12.334	515	232	VV	0.032	12.9506
73	12.386	1252	313	VV	0.054	31.4711
74	12.505	830	282	VV	0.043	20.8709
75	12.558	495	156	VV	0.053	12.4453
76	12.931	408	68	VV	0.089	10.2609

Total area TPA = 407622 (102.5)/43018.26 = 970 ppmv SPM 11/15/94

==

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank
ID#: 9411023-03A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6111105		Date of Collection: NA	
Dil. Factor:	1.0		Date of Analysis: 11/11/94	
Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

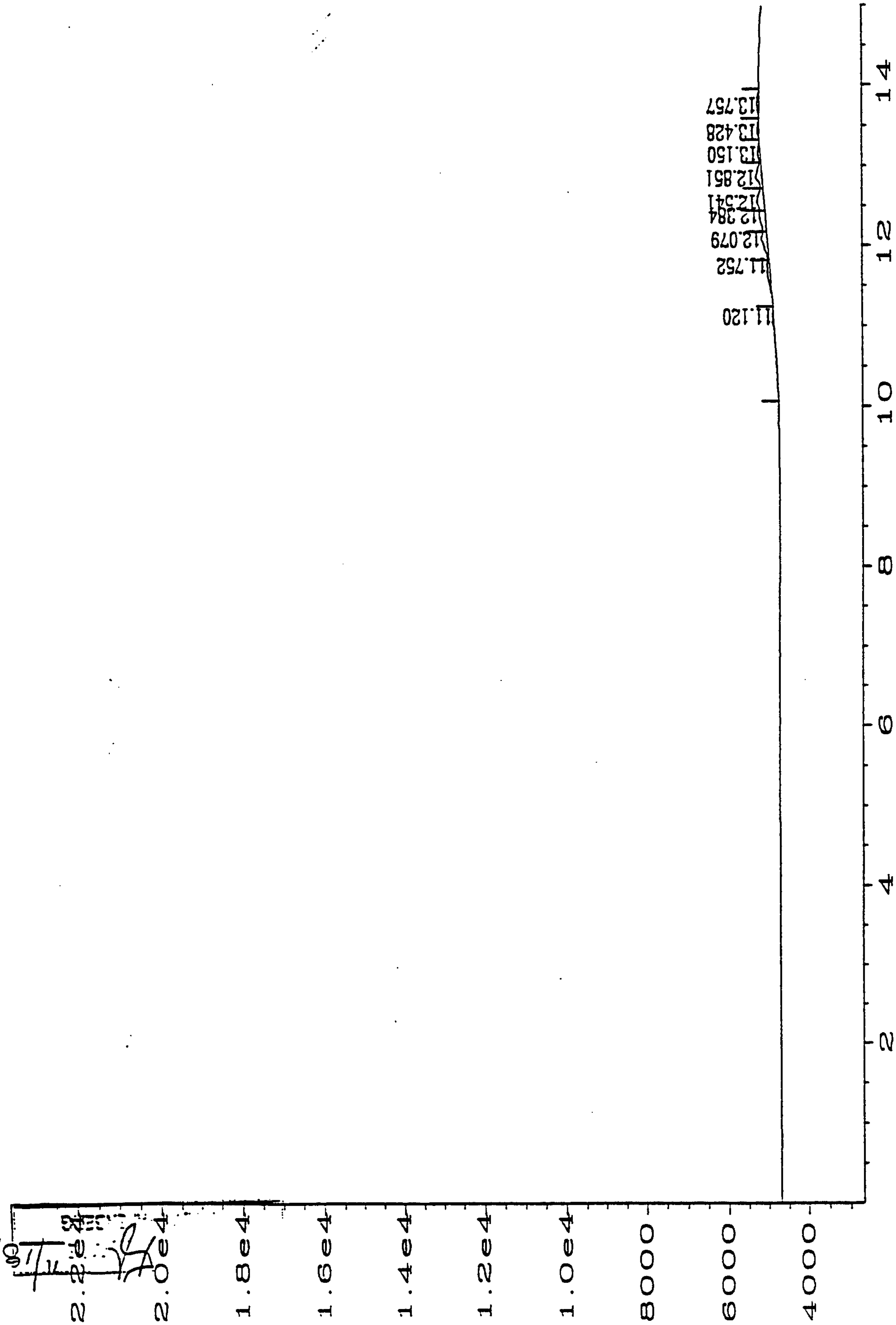
TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6111105		Date of Collection: NA	
Dil. Factor:	1.0		Date of Analysis: 11/11/94	
Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.010	0.065	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)

Container Type: NA

Sig. 1 in I:\CHEM\GC6.I\6-11NOV\6111105A.D



BLANK

External Standard Report

Data File Name : I:\CHEM\GC6.I\6-11NOV\6111105A.D
Operator : SPM
Instrument : GC_6
Sample Name : LAB BLANK
Run Time Bar Code:
Acquired on : 11 Nov 94 10:20 AM
Report Created on: 11 Nov 94 10:35 AM
Last Recalib on : 06 AUG 94 10:19 AM
Multiplier : 1
Sample Info : 250ML BLANK

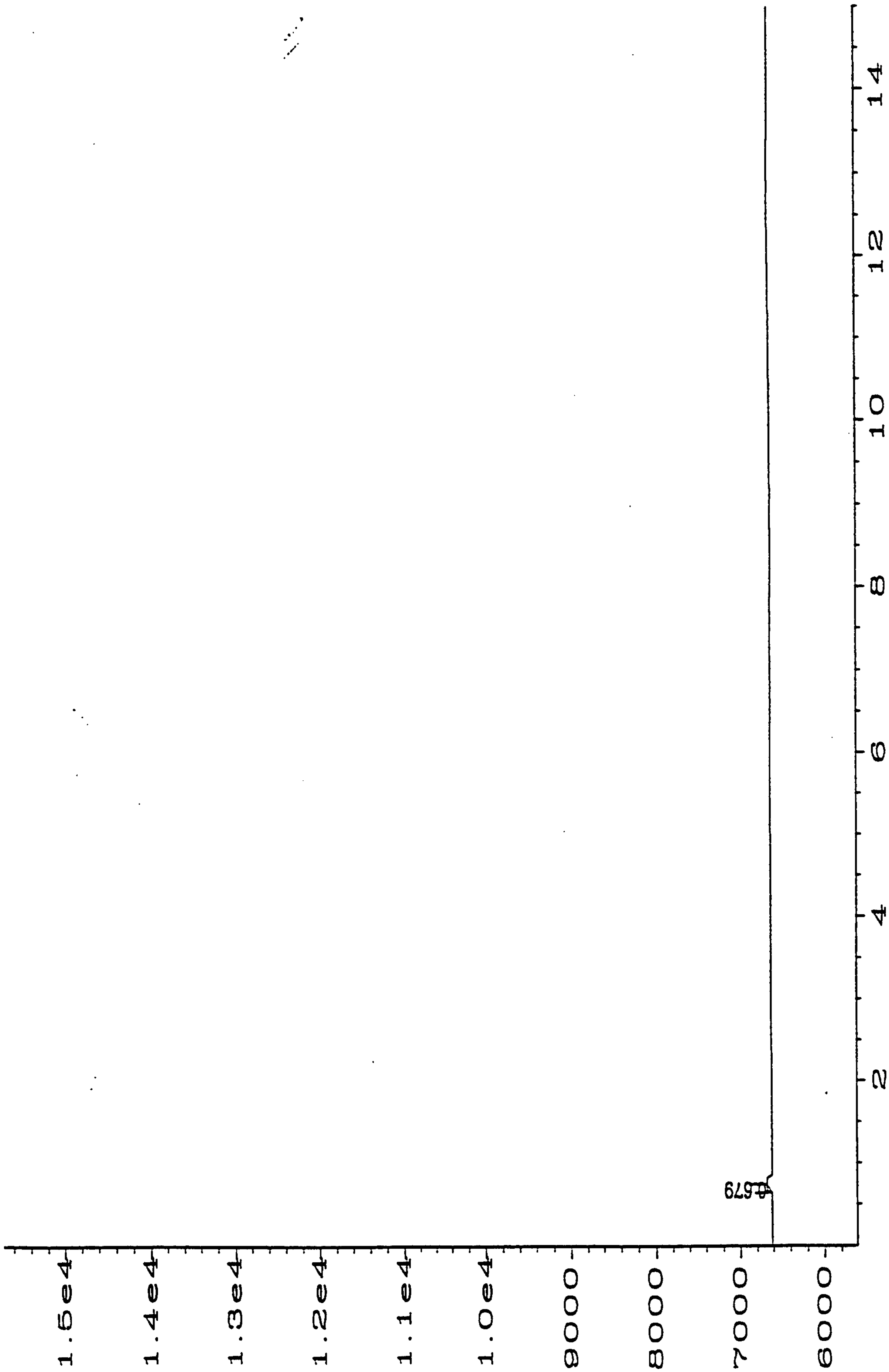
Page Number : 1
Vial Number :
Injection Number :
Sequence Line :
Instrument Method: BTEX1109.MTH
Analysis Method : BTEX1109.MTH
Sample Amount : 0
ISTD Amount :

Sig. 1 in I:\CHEM\GC6.I\6-11NOV\6111105A.D

Ret Time	Area	Type	Width	Ref#	ppmv	Name
3.569	* not found *			1	ND	MTBE
4.800	* not found *			1		BENZENE
6.500	* not found *			1		TOLUENE
9.100	* not found *			1		ETH.BNZ.
9.300	* not found *			1		M,P-XYLENE
9.850	* not found *			1		O-XYLENE
11.120	44	BV	0.050		43.663	* uncalibrated *
11.752	1123	PV	0.245		1123.151	* uncalibrated *
12.079	2028	VV	0.176		2027.861	* uncalibrated *
12.384	2004	VV	0.167		2003.980	* uncalibrated *
12.541	2314	VV	0.163		2314.128	* uncalibrated *
12.851	1972	VV	0.161		1972.002	* uncalibrated *
13.150	647	VB	0.139		646.834	* uncalibrated *
13.428	431	BV	0.122		430.949	* uncalibrated *
13.757	663	VB	0.166		663.404	* uncalibrated *

Not all calibrated peaks were found

Sig. 2 in I:\CHEM\GC6.I\6-11NOV\6111105B.D



Area Percent Report

Data File Name	: I:\CHEM\GC6.I\6-11NOV\6111105B.D		
Operator	: SPM	Page Number	: 1
Instrument	: GC_6	Vial Number	:
Sample Name	: LAB BLANK	Injection Number	:
Run Time Bar Code:		Sequence Line	:
Acquired on	: 11 Nov 94 10:20 AM	Instrument Method:	BTEX1109.MTH
Report Created on:	11 Nov 94 10:35 AM	Analysis Method	: TPH .MTH
Sample Info	: 250ML BLANK		

Sig. 2 in I:\CHEM\GC6.I\6-11NOV\6111105B.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	0.679	152	40	BB	0.053	100.0000

Total area = 152 MTD PRESSURE ≤MKF ND

SPM 11/11/94

AIR TOXICS LTD.
AN ENVIRONMENTAL ANALYTICAL LABORATORY

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX: (916) 985-1020

№ 002329

CHAIN-OF-CUSTODY RECORD

Contact Person MR. AL. POLLACK
Company BATTELLE MEMORIAL INSTITUTE
Address 505 KING AVE City COLUMBUS State OH Zip 43201
Phone (614) 424-3753 FAX (614) 424-3667

Project Info:
P.O. #
Project # 30B2001
Project Name BIOSLURPER

Turn Around Time:
☒ Normal
☐ Rush ______ Specify

Lab I.D.	Field Sample I.D.	Date & Time	Analyses Requested	Canister Pressure / Vacuum Initial	Final	Receipt
01A	WP-BIOSLURPER (PL-2) - #1	10/29/94 @ 1480h	BTEX/TPH referenced to JET FUEL (MODIFIED EPA TO-3)	30"Hg	ATM	1.0"Hg
02A	WP-BIOSLURPER (PL-2) - #2	10/31/94	BTEX/TPH as JET FUEL (MODIFIED EPA TO-3)	8.5"Hg	ATM	0.5"Hg

Collected By: Print M. PLACE / E. DRESCHER — Signature

Relinquished By: (Signature) Date/Time: Al Pollack 11/2/94 0900h — Received By: (Signature) Date/Time

Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time

Relinquished By: (Signature) Date/Time — Received By: (Signature) Date/Time: [signature] ATL 11/3/94 1030

Notes: GRAB SAMPLES OF STACK GAS OFF OF THE BIOSLURPER.

Lab Use Only	Shipper Name	Air Bill #	Opened By:	Date/Time	Temp. (°C)	Condition	Custody Seals Intact?	Work Order #
	Fed-X	229,3329797	TS	11/3/94 1030	Ambient	Good	Yes No (None)	9411023

Form 1293 rev 05

APPENDIX D

SOIL GAS PERMEABILITY TEST RESULTS

	Wright Patterson Air Force Base MP -A			
Time (min)	MPA-6	MPA-10	MPA-14	MPA-18
0	0	0	0	0
1		0.025	0.028	0.05
2		0.028	0.04	0.055
3		0.03	0.04	0.058
4		0.03	0.045	0.058
5		0.03	0.045	0.07
6		0.03	0.045	0.063
7		0.025	0.045	0.07
8		0.032	0.045	0.065
9		0.038	0.054	0.078
10	0.02	0.038	0.055	0.072
15		0.037	0.055	0.077
20		0.043	0.063	0.085
25		0.048	0.063	0.084
30	0.03	0.055	0.074	0.105
35				
40	0.03	0.055	0.084	0.115
50		0.06	0.095	0.125
65		0.065	0.1	0.145
75	0.03	0.07	0.1	0.15
90	0.03	0.08	0.115	0.155
110	0.05	0.09	0.125	0.165
145		0.02	0.04	0.07
249		0.03	0.05	0.075
569	0.01	0.03	0.05	0.08
1134	0.015	0.045	0.065	0.1
1364	0.02	0.06	0.08	0.12
1700	0.005	0.045	0.07	0.11
3113	0.01	0.05	0.08	0.12
3790	0.01	0.05	0.09	0.13
4717	0.01	0.055	0.09	0.135
5765	0.015	0.055	0.09	0.15

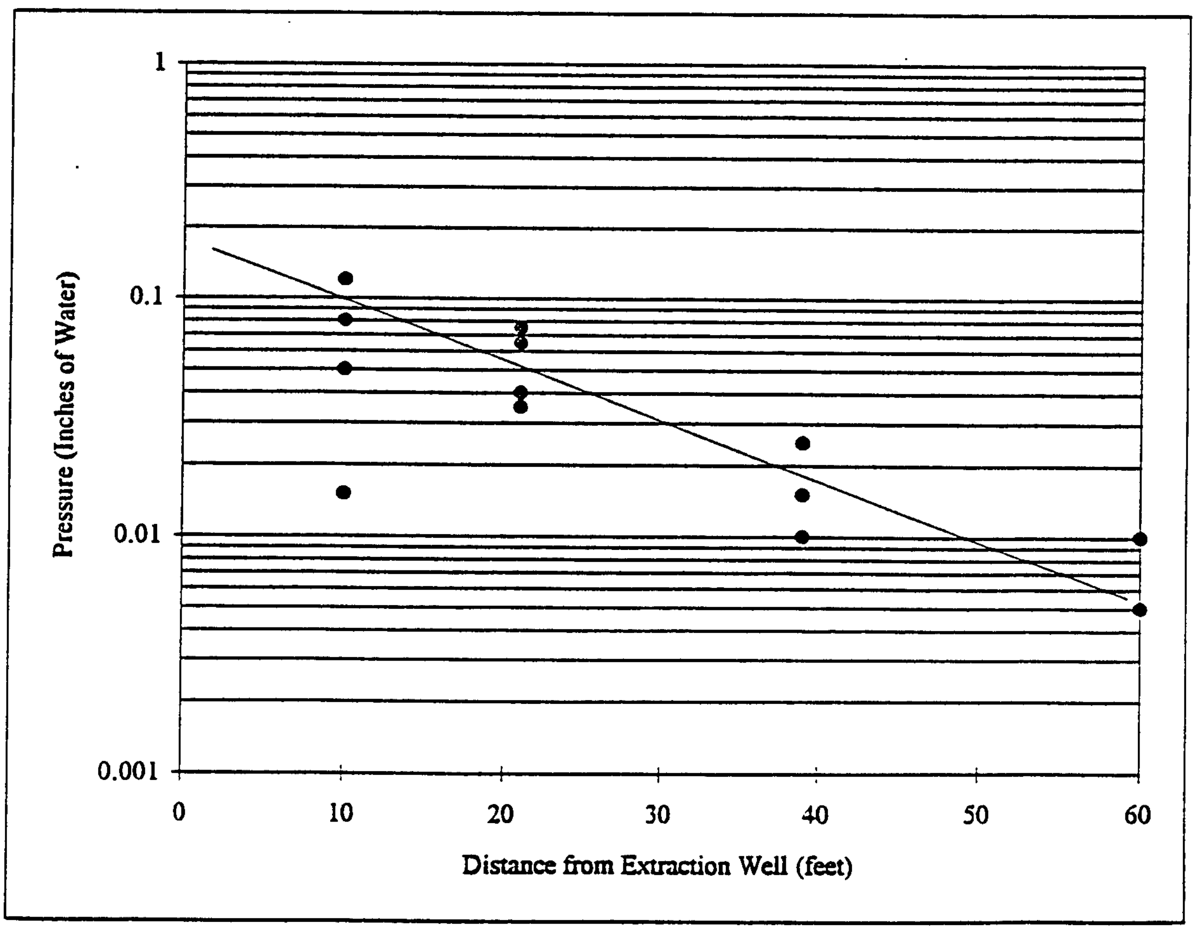
	Wright Patterson Air Force Base MP -B			
Time (min)	MPB-6	MPB-10	MPB-14	MPB-18
0	0	0	0	0
1		0.01	0.015	0.02
2		0.01	0.01	0.02
3		0.01	0.02	0.025
4		0.015	0.02	0.025
5		0.015	0.015	0.025
6		0.015	0.02	0.025
7		0.01	0.015	0.025
8		0.01	0.02	0.025
9		0.015	0.025	0.04
10	0.01	0.015	0.025	0.035
15		0.015	0.03	0.035
20		0.025	0.025	0.035
25		0.015	0.025	0.04
30	0.02	0.025	0.035	0.04
35		0.02	0.035	0.045
40		0.02	0.03	0.04
50		0.01	0.03	0.025
65		0.02	0.025	0.03
75		0.035	0.05	0.055
90		0.045	0.06	0.07
110		0.045	0.06	0.07
145		0	0	0.005
249		0	0.01	0.01
569		0	0.01	0.02
1134		0.017	0.03	0.035
1364	0.012	0.015	0.035	0.05
1700	0.03	0.03	0.05	0.055
3113	0.03	0.025	0.05	0.06
3790	0.03	0.03	0.06	0.07
4717	0.03	0.03	0.06	0.07
5765	0.035	0.04	0.065	0.075

	Wright Patterson Air Force Base MP -C			
Time (min)	MPC-6	MPC-10	MPC-14	MPC-18
0	0	0	0	0
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
15				
20				
25				
30				
35		0	0	0.005
40				
50				
65		0	0	0.005
75				
90				
110				
145				
249	0	0	0	0.005
569	0	0	0	0
1134	0	0	0.002	0.002
1364		0	0	0
1700		0.005	0.01	0.01
3113	0	0	0.005	0.01
3790	0	0	0.005	0.01
4717	0	0	0.01	0.01
5765	0	0	0.01	0.01

	Wright Patterson Air Force Base MP -D			
Time (min)	MPD-6	MPD-10	MPD-14	MPD-18
0	0	0	0	0
1		0	0	0.01
2		0	0.005	0.01
3		0	0.005	0.01
4		0	0.005	0.015
5		0	0.005	0.01
6		0	0.01	0.01
7		0	0.005	0.015
8		0	0.005	0.015
9		0	0.01	0.015
10		0	0.005	0.015
15		0	0.005	0.015
20		0.005	0.005	0.015
25		0	0.005	0.015
30		0	0.01	0.02
35				
40		0	0.01	0.02
50		0	0.005	0.015
65		0	0.005	0.02
75		0	0	0.02
90				
110		0.015	0.025	0.05
145		0	0.005	0.025
249		0	0	0.005
569		0	0	0.005
1134		0	0.005	0.01
1364		0	0.01	0.02
1700		0.01	0.015	0.025
3113		0	0.01	0.02
3790		0	0.01	0.025
4717		0	0.01	0.025
5765		0.01	0.015	0.025

Wright Patterson Air Force Base - Radius of Influence

Monitoring Point	Distance from Vent Well (ft)	Pressure (@ t=5765 min
MPA-6	10	0.015
MPA-10	10	0.05
MPA-14	10	0.08
MPA-18	10	0.12
MPB-6	21	0.035
MPB-10	21	0.04
MPB-14	21	0.065
MPB-18	21	0.075
MPC-6	60	
MPC-10	60	0.005
MPC-14	60	0.01
MPC-18	60	0.01
MPD-6	39	
MPD-10	39	0.01
MPD-14	39	0.015
MPD-18	39	0.025



dr // RADIUS.XLS

APPENDIX E

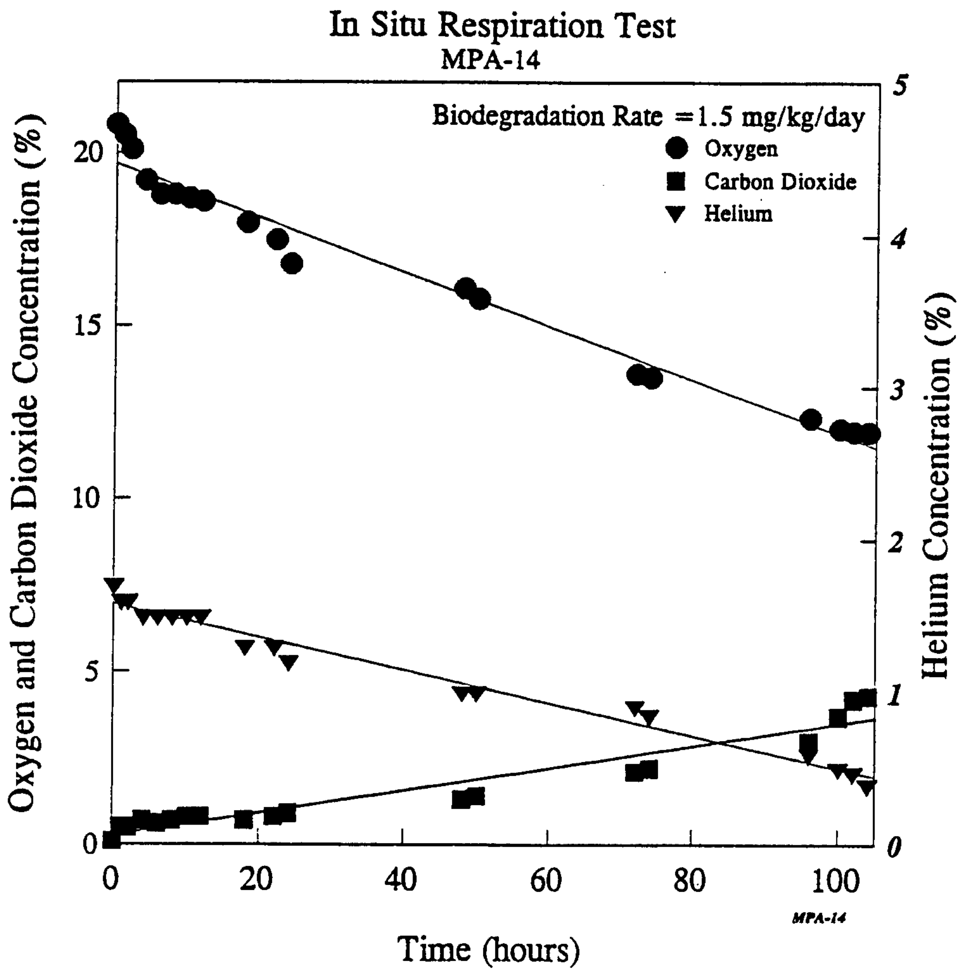
IN SITU RESPIRATION TEST RESULTS

Time (hrs)	MPA-14 Oxygen (%)	Carbon Dioxide (%)	Helium (%)	TPH (ppm)
0	20.80	0.10	1.70	250
1	20.50	0.50	1.60	240
2	20.10	0.50	1.60	240
4	19.20	0.70	1.50	240
6	18.80	0.60	1.50	240
8	18.80	0.70	1.50	240
10	18.70	0.80	1.50	240
12	18.60	0.80	1.50	250
18	18.00	0.70	1.30	260
22	17.50	0.80	1.30	260
24	16.80	0.90	1.20	260
48	16.10	1.30	1.00	250
50	15.80	1.40	1.00	250
72	13.60	2.10	0.91	230
74	13.50	2.20	0.85	240
96	12.30	3.00	0.59	210
100	12.00	3.70	0.50	220
102	11.90	4.20	0.47	210
104	11.90	4.30	0.39	210

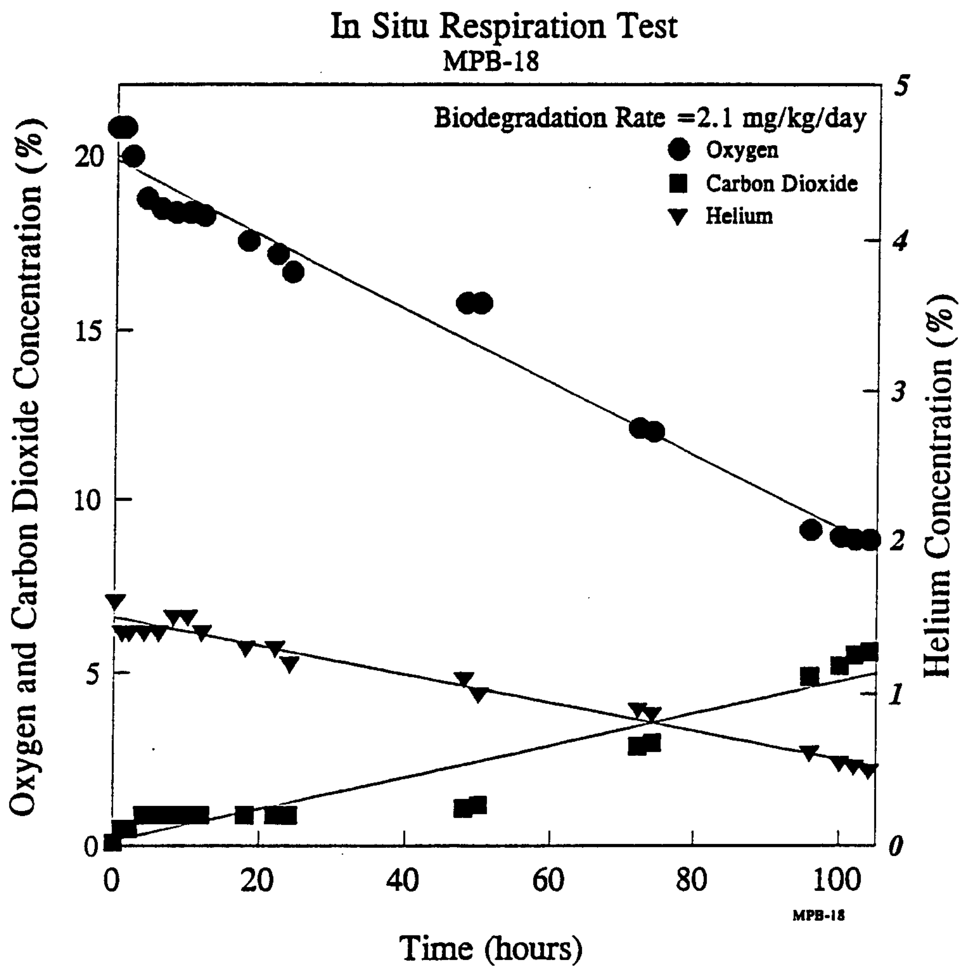
Time (hrs)	MPB-18 Oxygen (%)	Carbon Dioxide (%)	Helium (%)	TPH (ppm)
0	20.80	0.10	1.60	290
1	20.80	0.50	1.40	260
2	20.00	0.50	1.40	260
4	18.80	0.90	1.40	250
6	18.50	0.90	1.40	240
8	18.40	0.90	1.50	240
10	18.40	0.90	1.50	230
12	18.30	0.90	1.40	240
18	17.60	0.90	1.30	240
22	17.20	0.90	1.30	240
24	16.70	0.90	1.20	250
48	15.80	1.10	1.10	250
50	15.80	1.20	1.00	240
72	12.10	2.90	0.90	230
74	12.00	3.00	0.87	240
96	9.10	4.90	0.62	170
100	8.90	5.20	0.55	170
102	8.80	5.50	0.53	180
104	8.80	5.60	0.50	180

Time (hrs)	MPC-18 Oxygen (%)	Carbon Dioxide (%)	Helium (%)	TPH (ppm)
0	20.50	0.10	1.80	280
1	20.40	0.50	1.60	260
2	20.20	0.50	1.50	250
4	18.50	0.90	1.50	230
6	18.40	0.80	1.40	230
8	18.40	0.80	1.40	220
10	18.30	0.90	1.40	210
12	18.30	0.90	1.40	210
18	18.00	0.80	1.20	190
22	17.90	0.90	1.10	200
24	16.90	1.00	1.00	210
48	16.00	3.50	1.00	230
50	15.90	3.80	0.89	230
72	14.40	7.20	0.71	200
74	14.20	7.50	0.62	200
96	13.10	10.00	0.35	150
100	12.50	10.50	0.27	150
102	12.40	10.50	0.21	150
104	12.20	10.70	0.18	160

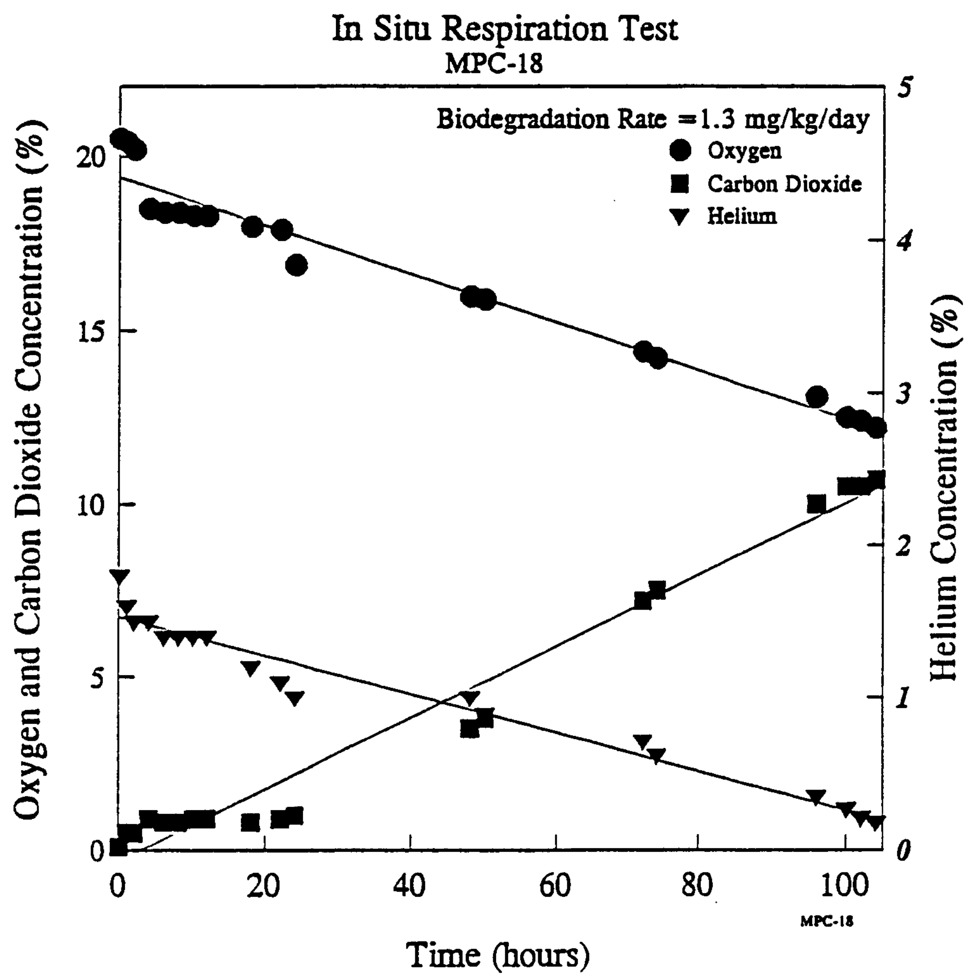
Time (hrs)	MPD-18 Oxygen (%)	Carbon Dioxide (%)	Helium (%)	TPH (ppm)
0	20.90	0.10	1.60	200
1	20.70	0.10	1.50	190
2	19.90	0.50	1.50	190
4	17.80	0.80	1.50	190
6	17.20	0.80	1.40	190
8	17.00	0.90	1.40	190
10	17.00	0.90	1.40	200
12	16.90	0.90	1.40	190
18	14.90	1.70	1.20	180
22	11.50	3.50	1.20	190
24	8.50	6.50	1.10	200
48	7.20	7.50	1.10	210
50	7.00	7.90	0.97	200
72	4.50	10.00	0.81	190
74	4.50	10.50	0.80	190
96	3.00	12.80	0.46	170
100	2.90	13.00	0.41	170
102	2.90	13.20	0.38	180
104	2.90	13.30	0.35	180

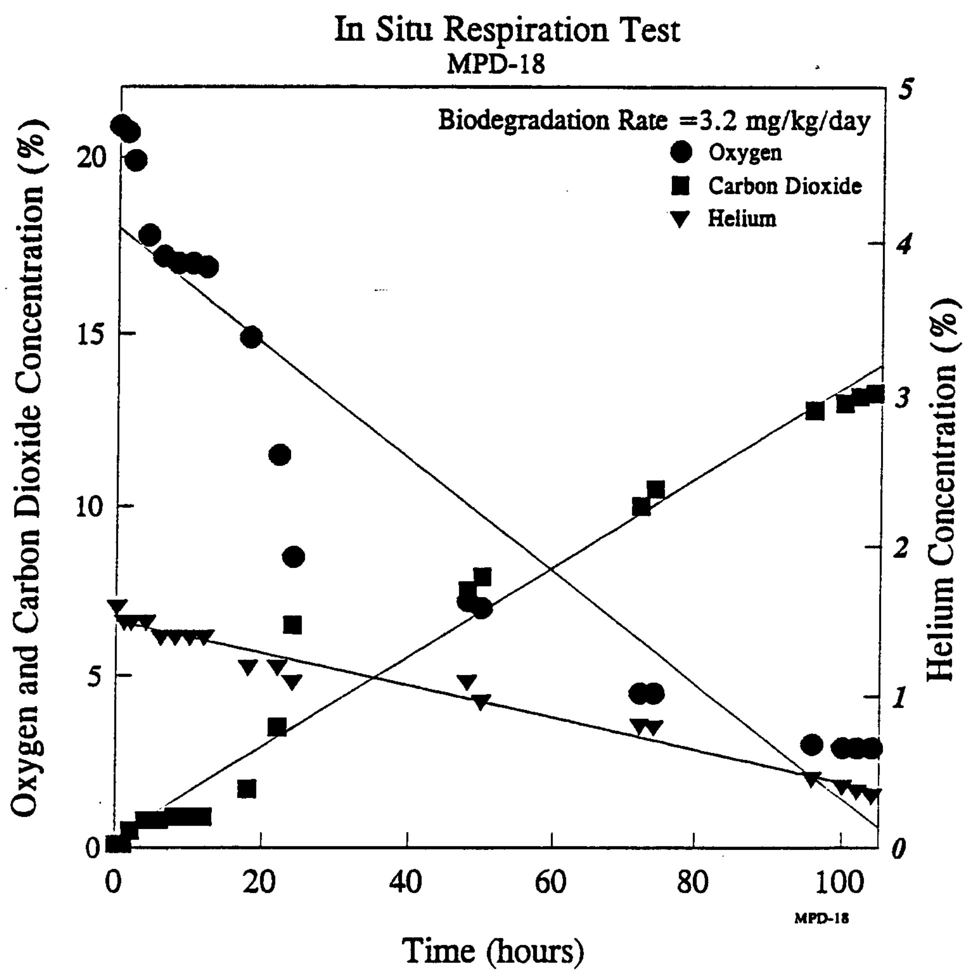


In Situ Respiration Test
MPA-14
Biodegradation Rate =1.5 mg/kg/day
Oxygen
Carbon Dioxide
Helium
Oxygen and Carbon Dioxide Concentration (%)
Helium Concentration (%)
Time (hours)
0
5
10
15
20
0
1
2
3
4
5
0
20
40
60
80
100
MPA-14



In Situ Respiration Test
MPB-18
Biodegradation Rate =2.1 mg/kg/day
Oxygen
Carbon Dioxide
Helium
Oxygen and Carbon Dioxide Concentration (%)
Helium Concentration (%)
Time (hours)
MPB-18
0
20
40
60
80
100
5
10
15
1
2
3
4

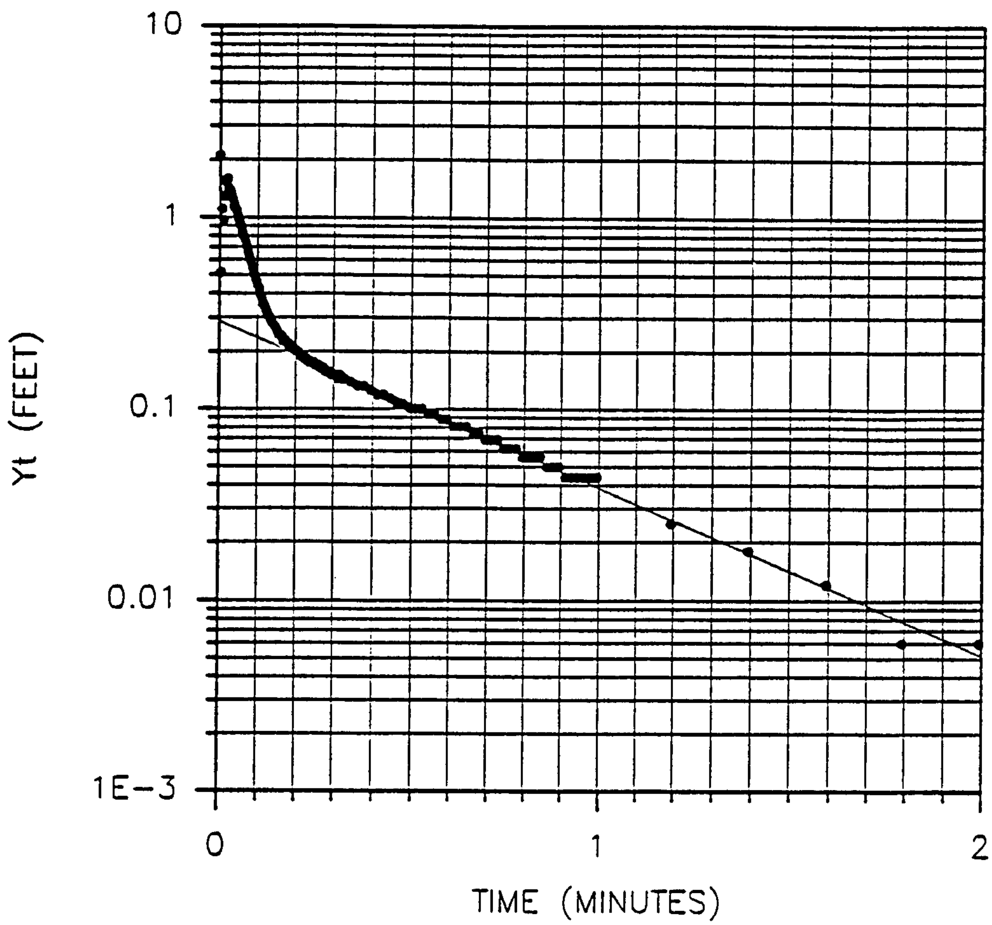

In Situ Respiration Test
MPC-18
Biodegradation Rate =1.3 mg/kg/day
Oxygen
Carbon Dioxide
Helium
Oxygen and Carbon Dioxide Concentration (%)
Helium Concentration (%)
0
20
40
60
80
100
MPC-18
Time (hours)
0
5
10
15
20
0
1
2
3
4
5



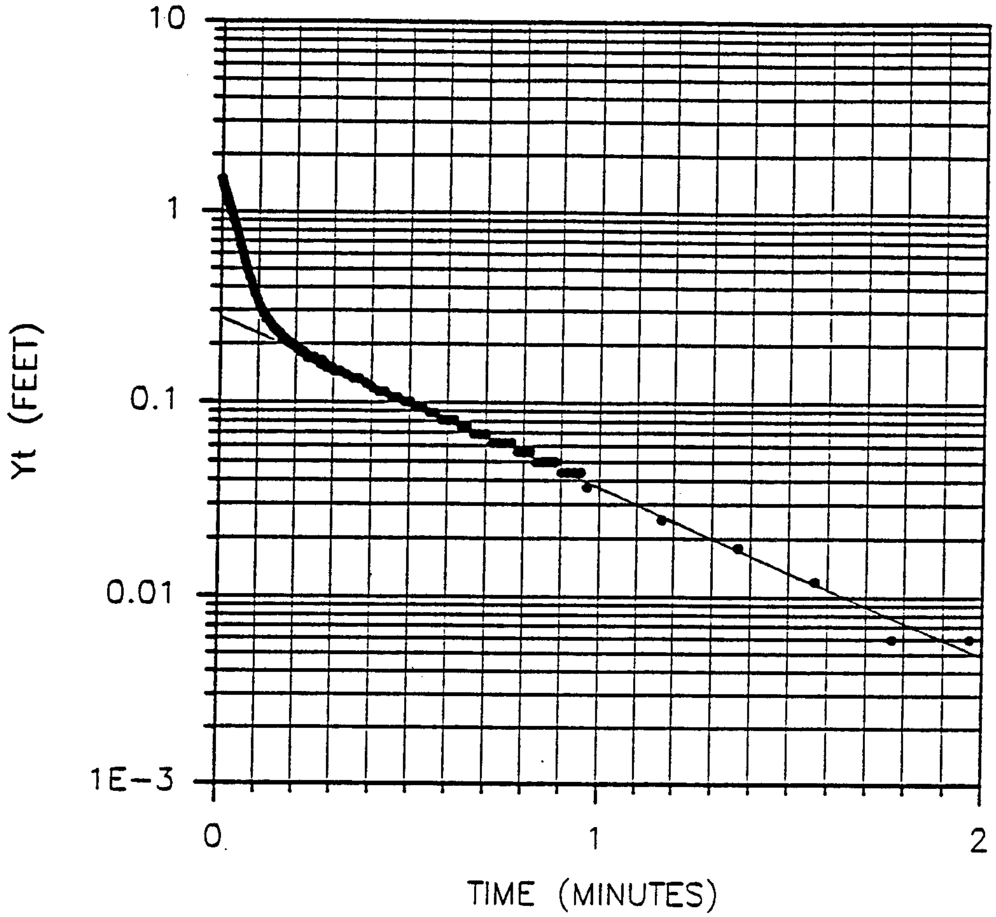
In Situ Respiration Test
MPD-18
Biodegradation Rate =3.2 mg/kg/day
Oxygen
Carbon Dioxide
Helium
Oxygen and Carbon Dioxide Concentration (%)
Helium Concentration (%)
Time (hours)
MPD-18
0
5
10
15
20
0
20
40
60
80
100
0
1
2
3
4
5

APPENDIX F

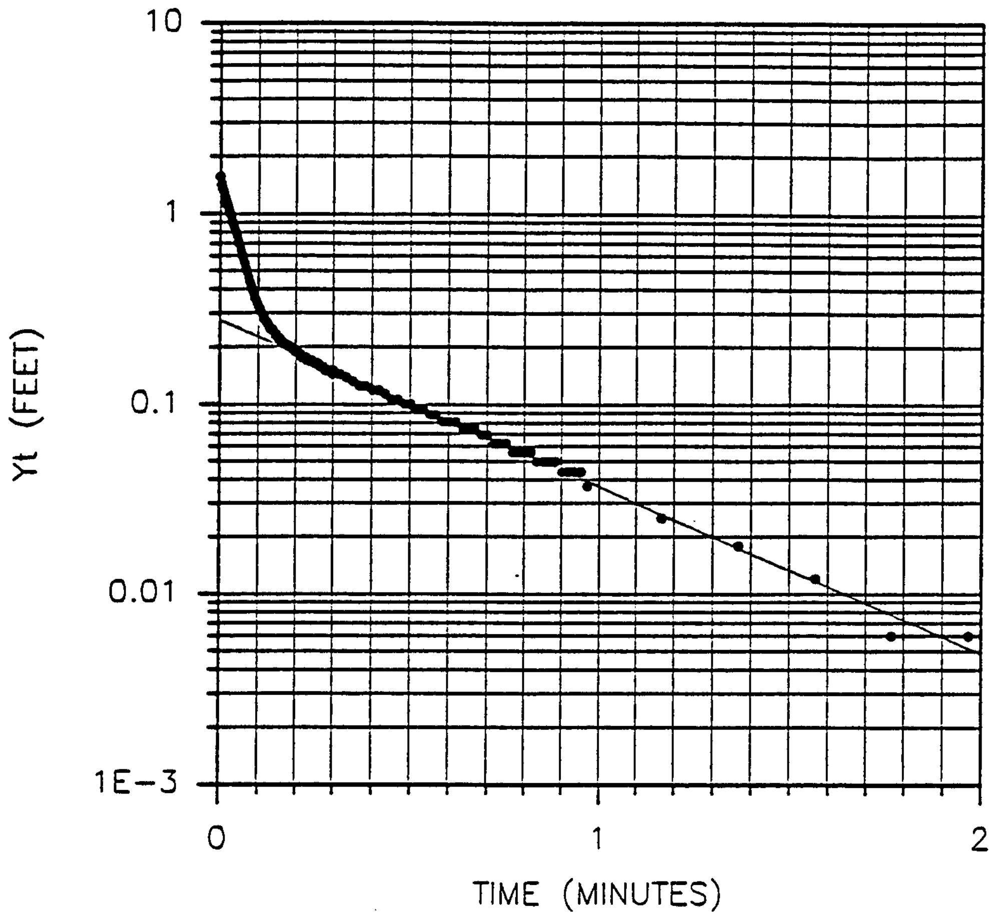
SLUG TESTING RESULTS



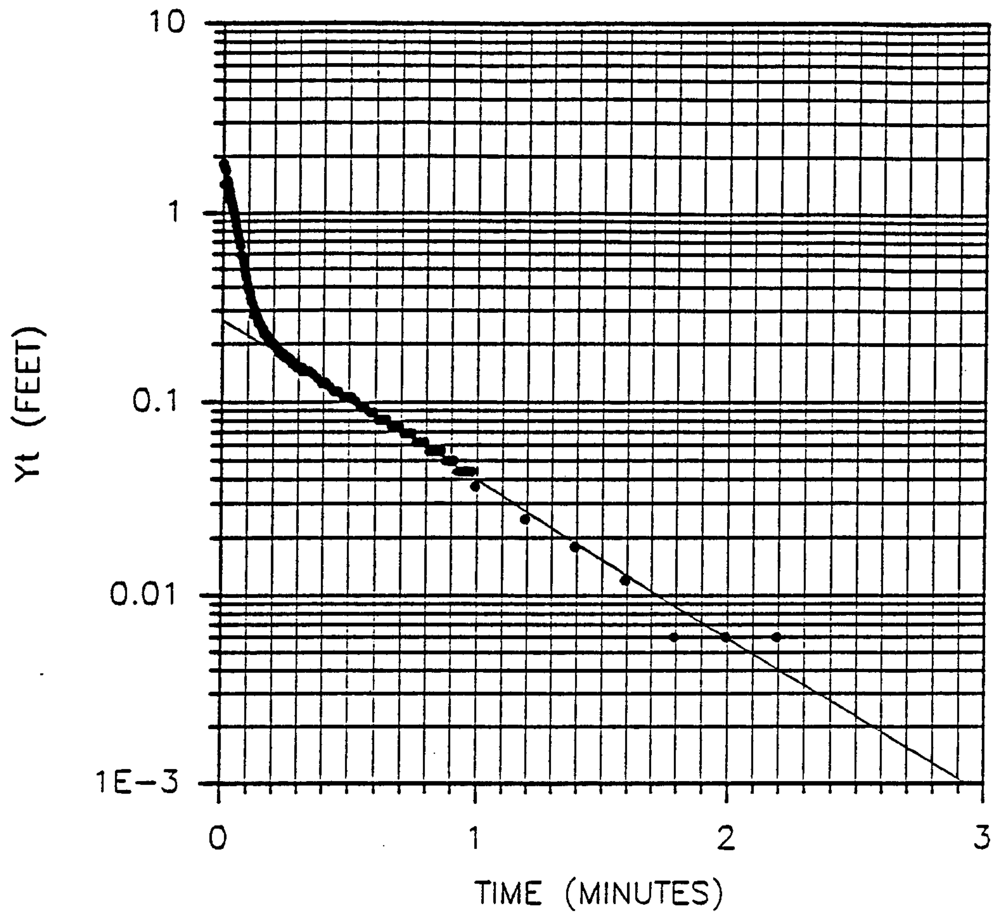
Bouwer and Rice Slug Test Analysis						
Well P6-1 - Replicate #1						
D =	30	ft				
L =	10	ft				
H =	7.76	ft				
rw =	0.354	ft				
rc =	0.166	ft				
L/rw =	28.25			ln Re/rw =	1.50	
A =	2.1			Re =	1.59	
B =	1.6					
t =	1	min		K =	5.98	ft/day
Yt =	0.039	ft				
Yo =	0.29	ft				



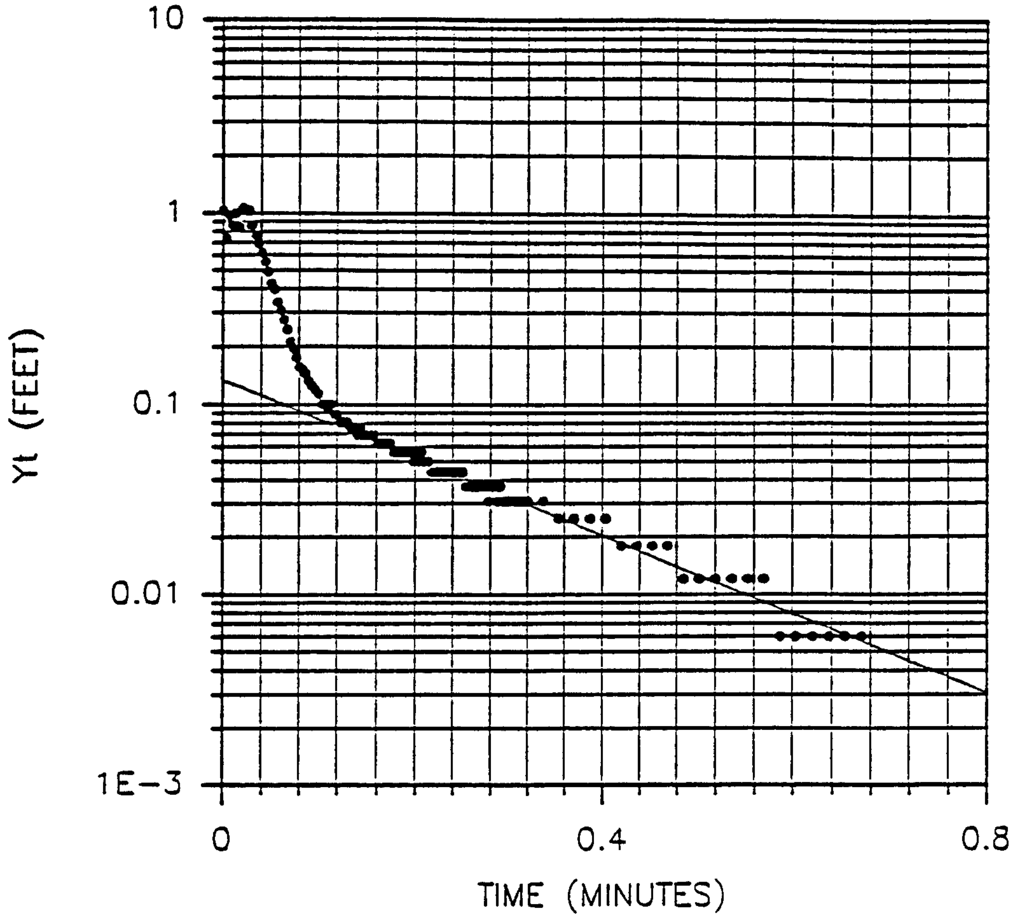
Bouwer and Rice Slug Test Analysis					
Well P6-1 - Replicate #2					
D =	30	ft			
L =	10	ft			
H =	7.76	ft			
rw =	0.354	ft			
rc =	0.166	ft			
L/rw =	28.25			ln Re/rw =	1.50	
A =	2.1			Re =	1.59	
B =	1.6					
t =	1.1	min		K =	6.15	ft/day
Yt =	0.03	ft				
Yo =	0.29	ft				



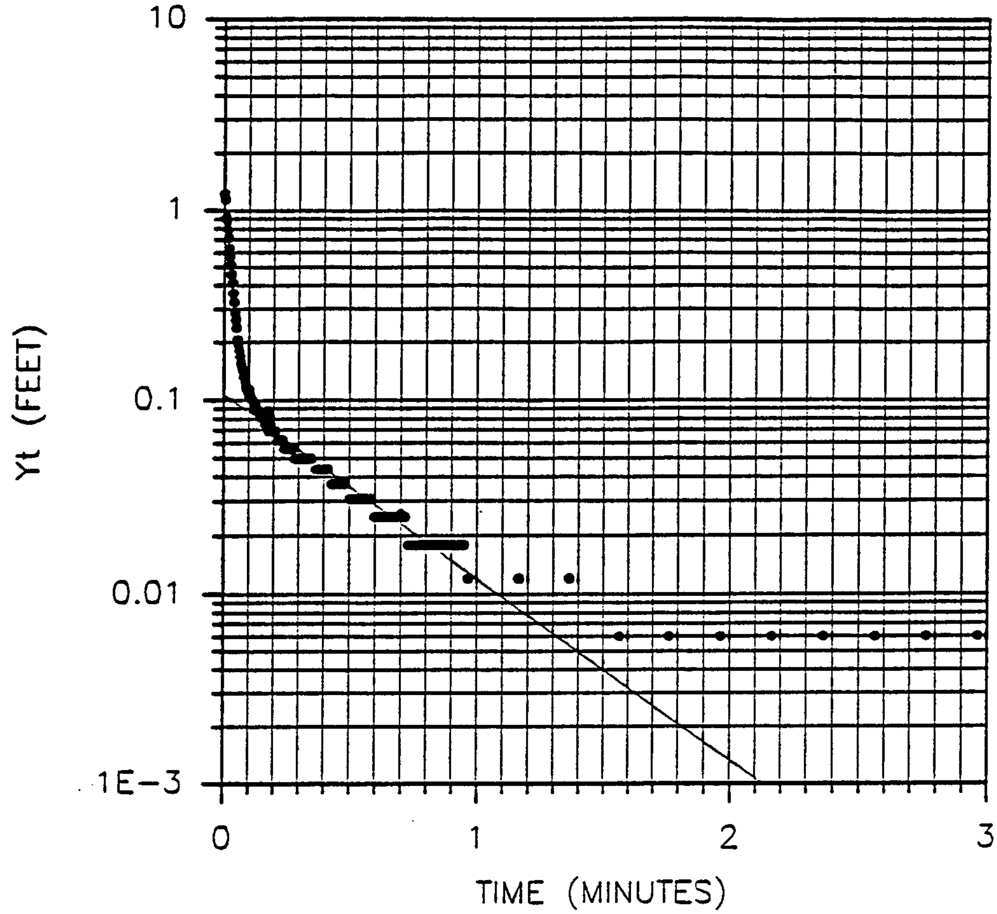
Bouwer and Rice Slug Test Analysis						
Well P6-1 - Replicate #3						
D =	30	ft				
L =	10	ft				
H =	7.76	ft				
rw =	0.354	ft				
rc =	0.166	ft				
L/rw =	28.25			ln Re/rw =	1.50	
A =	2.1			Re =	1.59	
B =	1.6					
t =	1.1	min		K =	6.15	ft/day
Yt =	0.03	ft				
Yo =	0.29	ft				



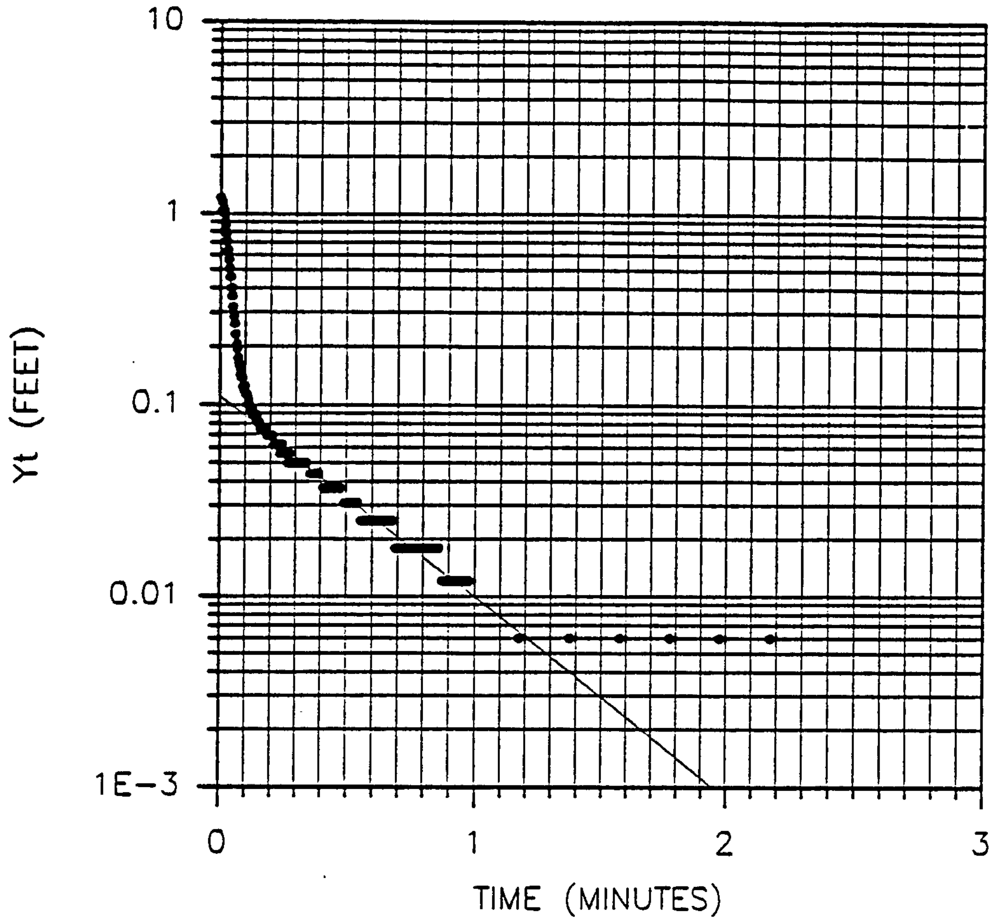
Bouwer and Rice Slug Test Analysis						
Well P6-1 - Replicate #4						
D =	30	ft				
L =	10	ft				
H =	7.76	ft				
rw =	0.354	ft				
rc =	0.166	ft				
L/rw =	28.25			ln Re/rw =	1.50	
A =	2.1			Re =	1.59	
B =	1.6					
t =	1	min		K =	5.58	ft/day
Yt =	0.04	ft				
Yo =	0.26	ft				



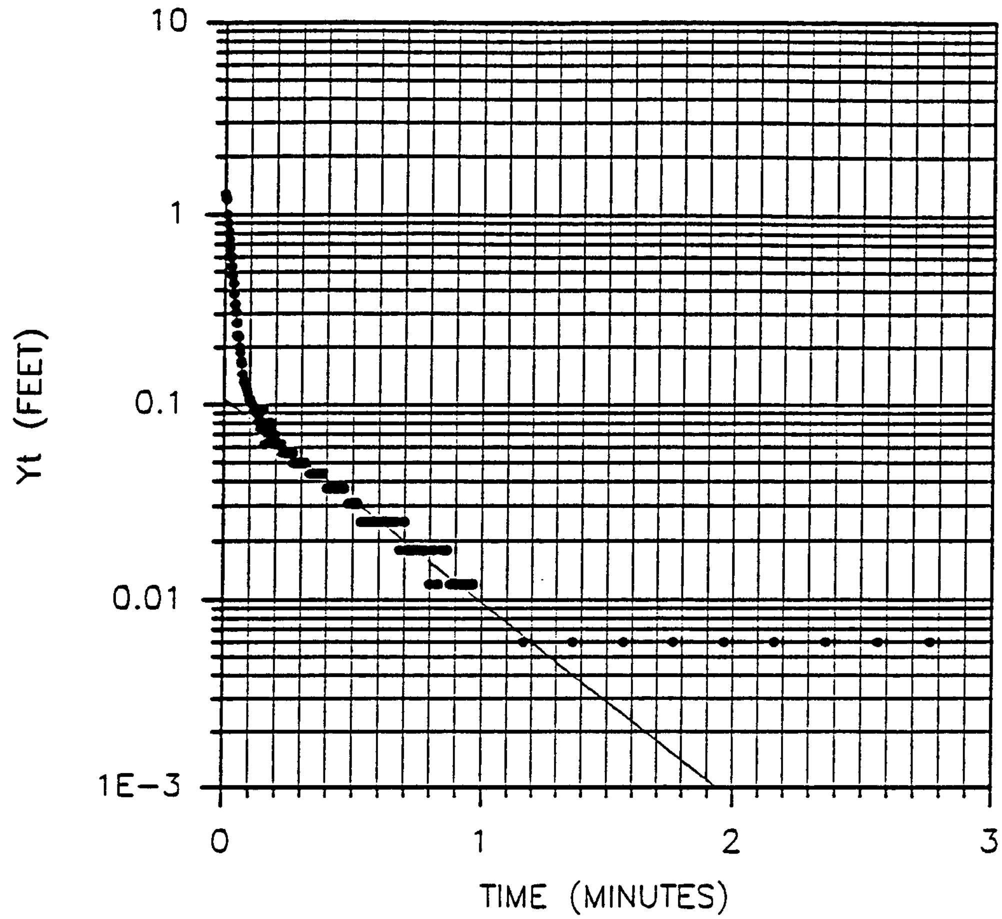
Bouwer and Rice Slug Test Analysis						
Well P6-2 - Replicate #1						
D =	30	ft				
L =	10	ft				
H =	7.62	ft				
rw =	0.354	ft				
rc =	0.166	ft				
L/rw =	28.25			ln Re/rw =	1.50	
A =	2.1			Re =	1.58	
B =	1.6					
t =	1	min		K =	5.78	ft/day
Yt =	0.02	ft				
Yo =	0.14	ft				



Bouwer and Rice Slug Test Analysis					
Well P6-2 - Replicate #2					
D =	30	ft			
L =	10	ft			
H =	7.62	ft			
rw =	0.354	ft			
rc =	0.166	ft			
L/rw =	28.25			ln Re/rw =	1.50
A =	2.1			Re =	1.58
B =	1.6				
t =	1	min		K =	6.21	ft/day
Yt =	0.013	ft			
Yo =	0.105	ft			



Bouwer and Rice Slug Test Analysis						
Well P6-2 - Replicate #3						
D =	30	ft				
L =	10	ft				
H =	7.62	ft				
rw =	0.354	ft				
rc =	0.166	ft				
L/rw =	28.25			ln Re/rw =	1.50	
A =	2.1			Re =	1.58	
B =	1.6					
t =	1	min		K =	6.99	ft/day
Yt =	0.01	ft				
Yo =	0.105	ft				



Bouwer and Rice Slug Test Analysis						
Well P6-2 - Replicate #4						
D =	30	ft				
L =	10	ft				
H =	7.62	ft				
rw =	0.354	ft				
rc =	0.166	ft				
L/rw =	28.25			ln Re/rw =	1.50	
A =	2.1			Re =	1.58	
B =	1.6					
t =	1	min		K =	7.14	ft/day
Yt =	0.0095	ft				
Yo =	0.105	ft				

APPENDIX G

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER FIELD ACTIVITIES AT WRIGHT-PATTERSON AFB, OHIO

For Review and Approval

Name		Initials	Date
Originator	JA Kittel	[illegible]	10/18/94
Approved	JL Means	[illegible]	10/2-/94

SENT VIA: Fax and First Class Mail

No. G4622-1001 (3171)

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October 18, 1994

Mr. Patrick E. Haas
Headquarters Air Force Center for
Environmental Excellence
8001 Arnold Drive (Bldg. 642)
Brooks AFB, Texas 78235-5357

Dear Mr. Haas:

TEST PLAN FOR BIOSLURPER FIELD ACTIVITIES AT WRIGHT-PATTERSON AFB, OHIO

This letter report was developed to accompany the 1994 draft report titled, *Test Plan and Technical Protocol for a Field Treatability Test for Bioslurping*. This draft test plan document was developed as a generic test plan to be used for the Air Force Bioslurper Initiative Project in which Wright-Patterson AFB is participating. This letter outlines all the site-specific information that was received by Battelle from Wright-Patterson AFB, as well as pertinent information that supports the generic test plan.

The site-specific information that was received included data for Spill Site 5 and Tank Farm F at Wright-Patterson AFB. From an initial review of the data, it is anticipated that an area between Tank Farm F and Spill Site 5 will be the site selected for the bioslurper pilot test. Specifically, well #P6-2 appears to be the best candidate for the bioslurper field test. If digging permits will be required, then Battelle and Wright-Patterson AFB staff will coordinate to obtain the required permits prior to bioslurper well installation.

Site Description

Figure 1 is a map that depicts the two areas of interest at Wright-Patterson AFB. In the attachments to this letter, there is a boring log for well #P6-2 (which has shown free product during the past year), and there are well construction diagrams for well #P6-1 and P6-2. From the data received it is known that well #P6-2 has shown 0.9 ft of free product as of October 14, 1994. Initial site characterization tests will be performed at this well, which is located between Spill Site 5 and Tank Farm F. The data for Wright-Patterson AFB suggest that well #P6-2 will be the best candidate for the bioslurper recovery well.

At Wright-Patterson AFB, it is known that the existing fuel plume that is contaminating the soil and groundwater is JP-4 jet fuel. The soil gas vapor TPH and benzene concentrations range from 8.0 to 8.2 mg/L and 0.001 to 0.002 mg/L, respectively, at Wright-Pat AFB.

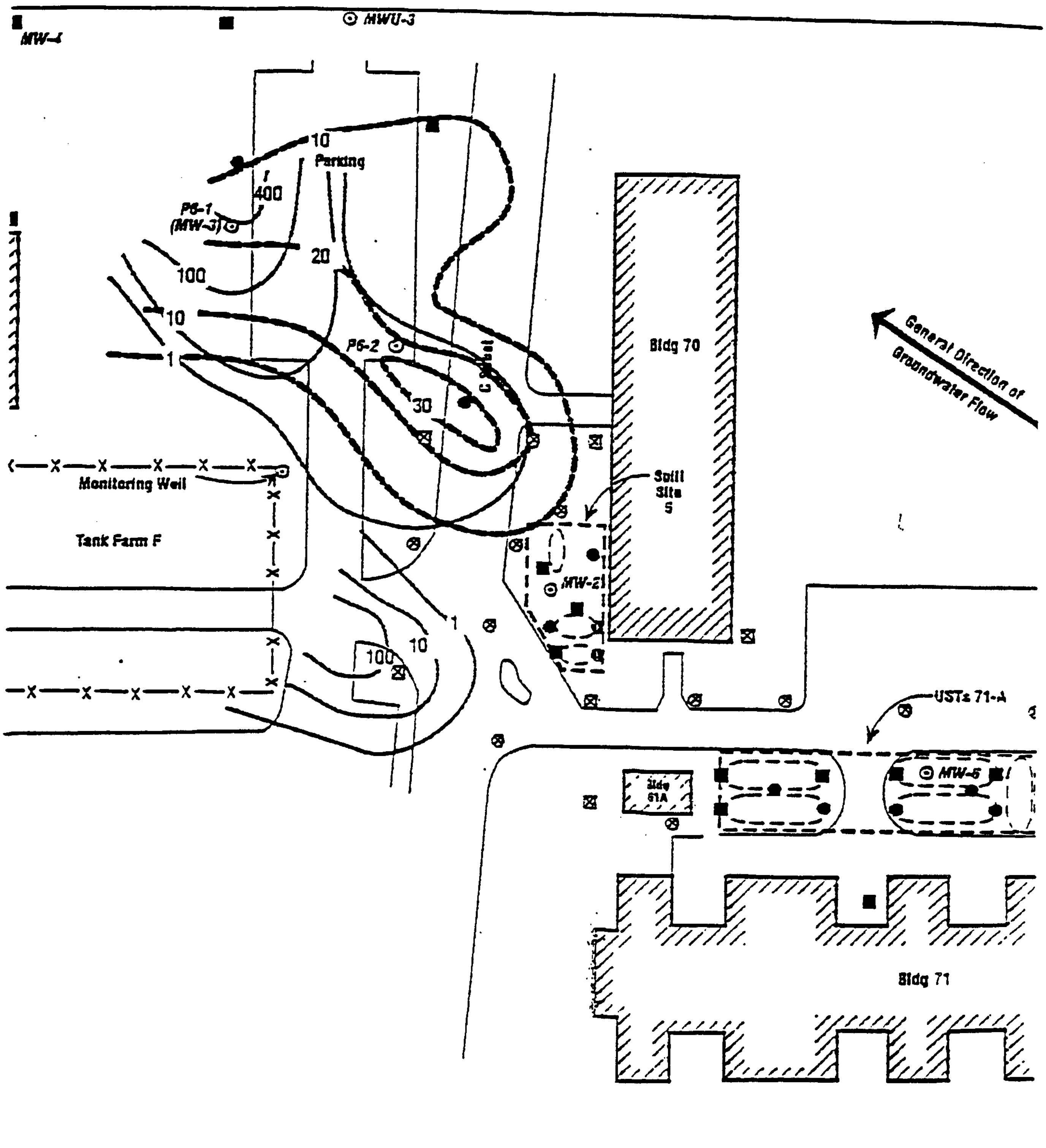


Figure 1. Site Map for Wright-Patterson AFB

<u>Project Activities</u>

The following field activities are planned for the bioslurper pilot test at Wright-Patterson AFB. Additional detail about the activities is located in the draft Test Plan and Technical Protocol report. Table 1 is the schedule of activities for the bioslurper initiative at Wright-Patterson AFB.

1. MOBILIZATION TO THE SITE

Battelle staff will mobilize equipment to the test site when the site specific test plan is approved. All equipment will be driven by Battelle staff to Wright-Patterson AFB. The base Point of Contact (PoC) will have been asked in advance to find a suitable location to setup the bioslurper pilot test equipment, so that it is easily installed next to well #P6-2. Battelle personnel will be mobilized to the site on October 20, 1994. The following table provides the Air Force PoC with personal information for each Battelle employee that will be on site. The expected mobilization to the site will be October 20, 1994. If any changes from this date occur the Wright-Patterson PoC will be notified.

<u>Name</u>
Eric Drescher
Matt Place
Jon Eastep
Greg Headington
Jeffrey A. Kittel

PII Redacted

[redacted]

2. SITE CHARACTERIZATION TESTS

2.1 Soil Gas Survey (Limited)

A small-scale soil gas survey will be conducted to in the area that has been cleared by the digging permits for installation of the bioslurping system. The area around these wells will be surveyed to select the locations for installation of soil gas monitoring points and will follow the criteria below:

1. Soil vapor from the site will exhibit high TPH concentrations (10,000 ppm or greater).

2. Relatively low oxygen concentrations (between 0% and 2%).

3. Relatively high carbon dioxide concentrations (depending on soil type, between 2% and 10% or greater).

To obtain further information about the soil gas survey, consult the test plan and technical protocol (see Sec. 5.2 and 5.8).

Table 1. Schedule of Activities for Bioslurper Initiative

Pilot Test Activity	Schedule
Test Plan Approval	day (to be determined)
Mobilization	day 1-2
Site Characterization	day 2-3
Baildown Tests	
Slug Test	
Soil Gas Survey (limited)	
Monitoring Point Installation (3 MPs)	
Soil Sampling	
System Installation	day 2-3
Test Startup	day 4
Skimmer Test (1 day)	day 4
Bioslurper Pump Test (4 days)	day 5-9
Air Permeability Testing	day 5
Drawdown Pump Test (1 day)	day 9
In Situ Respiration Test (air/helium injection)	day 9
In Situ Respiration Test (monitoring)	day 10-12
Demobilization/Mobilization	day 12-14

2.2 Baildown tests

Baildown tests will be performed at well #P6-2, which contains measurable light non-aqueous phase liquid (LNAPL) thickness. This will be done to estimate the LNAPL recovery potential at that particular well. Procedural information about the baildown tests can be found in the test plan and technical protocol (see Sec. 5.6).

2.3 Slug Tests

Slug tests will be performed to determine the characteristics of the aquifer where the candidate well is located. These tests will be performed using an in situ pressure transducer and data logger, as well as a PVC capsule to be used as the slug. The slug tests will be performed at a later date. The Wright-Patterson AFB PoC will be informed of the date prior to testing. Additional information about the slug tests can be found in the draft Test Plan and Technical Protocol (see Sec. 5.7).

2.4 Monitoring Point Installations

Upon the conclusion of the initial soil gas survey, baildown tests, and slug tests, at least three soil gas monitoring points will be installed. These monitoring points should be within the free-phase plume, and should allow for close monitoring of the in situ changes in soil gas composition caused by the bioslurper system. Information on monitoring point installation can be found in the draft Test Plan and Technical Protocol (see Sec. 4.2.1).

2.5 Soil Sampling

Soil samples of the chosen site will be collected from boreholes advanced for monitoring point installation. Two to three soil samples will be collected in each area that is being characterized. The samples will be collected at various depths in the soil profile to allow for the adequate characterization of both the vadose zone and capillary fringe of the free phase plume. The samples will be analyzed for total phosphorous; total Kjedahl nitrogen, alkalinity; pH; total iron; particle size distribution; bulk density; porosity; moisture content; BTEX; and TPH. The draft Test Plan and Technical Protocol will be consulted for information on the necessary field measurements and sample collection procedures for soil sampling (see Sec. 5.5.1).

3. BIOSLURPER SYSTEM INSTALLATION

Once site characterization data collection is complete at Wright-Patterson AFB, the bioslurper system will be constructed at Well #P6-2. Figure 2 shows a flow diagram of the bioslurper process. Figure 3 is a generic diagram of the bioslurper extraction well that will be installed at Wright-Patterson AFB. Prior to initiating the LNAPL recovery tests, all the relevant baseline field data will be collected and recorded. These data will include soil gas concentrations, initial soil gas pressures, the depth to groundwater, and the LNAPL thickness. Also, ambient soil and all the atmospheric conditions (weather conditions, temperature, humidity, barometric pressure, etc.) will be recorded. All emergency equipment (i.e. emergency shutoff switches and fire extinguishers) will be installed and

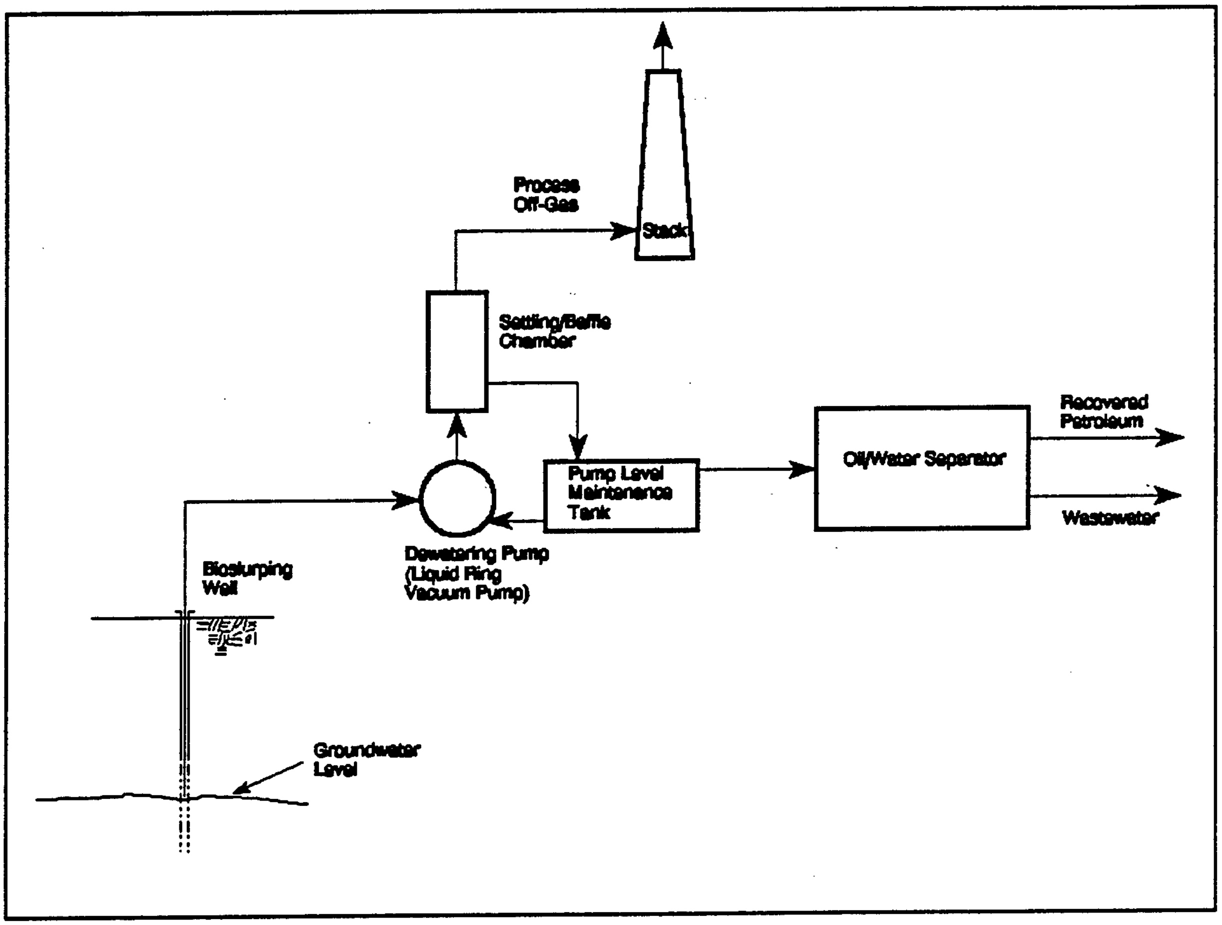


Figure 2. Bioslurper Process Flow Diagram

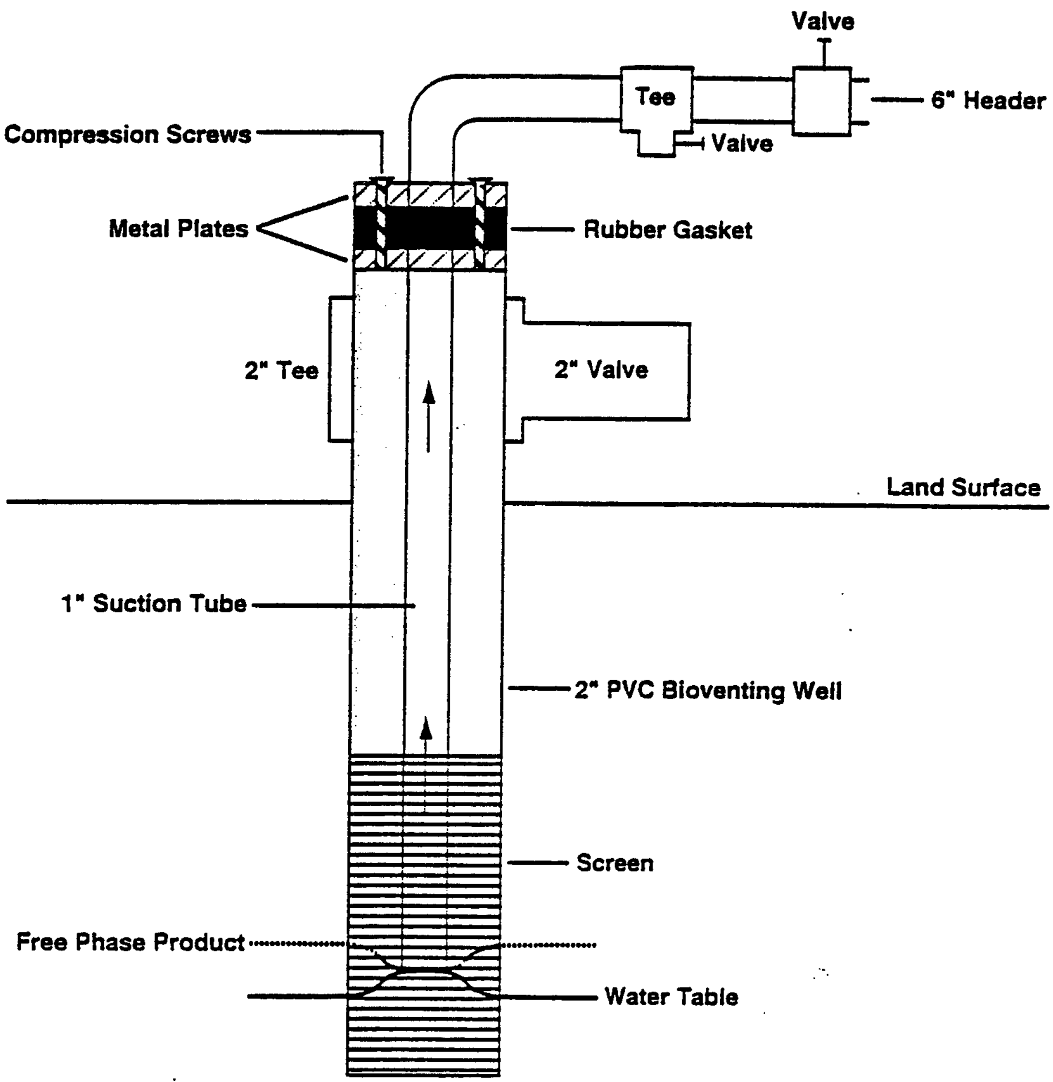


Figure 3. Diagram of a Typical Bioslurper Well

checked for proper operation at this time. Since well #P6-2 will most likely be used for the installation of the bioslurper extraction well, it will necessary to acquire space next to well #P6-2 for the 20' by 10' flatbed that will house the 5-hp pump and all other necessary equipment that will be used to perform the bioslurper tests at Wright-Patterson AFB. For more information on the bioslurper system installation consult the test plan and technical protocol (see Sec. 6.0).

3.1 System Shakedown

A brief startup test will be conducted to ensure that the system is properly constructed and safely operates. All system components will be checked for problems and/or malfunctions. A simple checklist will be provided to document the system shakedown.

3.2 System Startup

After installation is complete and the bioslurper system is confirmed to be operating properly, the LNAPL recovery tests will be started. The Bioslurper Initiative Project has been designed to evaluate the effectiveness of bioslurping as a LNAPL recovery technology relative to conventional gravity-driven LNAPL recovery technologies. The Bioslurper Initiative includes three separate LNAPL recovery tests: (1) a skimmer simulation test; (2) a vacuum-assisted bioslurper test; and (3) a groundwater drawdown LNAPL recovery test. The three recovery tests are described in detail in the draft Test Plan and Technical Protocol (see Sec. 7.3).

During the bioslurper tests the system will be monitored by taking soil gas measurements, samples of the soil and influent/effluent gases to the bioslurper system, and samples of the product (JP-4 jet fuel) being pulled from the contaminated area will be taken. Refer to the draft test plan and technical protocol for information about the process monitoring of the bioslurper system (see Sec. 8.0).

3.3 Soil Gas Permeability Tests

A soil gas permeability test will be conducted to estimate the vadose zone radius of influence of the bioslurper system. Results of the permeability testing will help in determining the number of wells that will be required to scale up the bioslurper system to treat the entire site. Refer to the test plan and technical protocol for further information on the soil gas permeability tests that will be conducted (see Sec. 5.8).

3.4 In Situ Respiration Tests

In situ respiration testing will be conducted at the site following the end of the bioslurper pump test. The in situ respiration testing will consist of air/helium injection into selected soil gas monitoring points, and the monitoring of the changes in concentration of oxygen, carbon dioxide, petroleum hydrocarbons, and helium. The rate of oxygen utilization will be used to estimate the biodegradation rate for the site. Further information on the procedures and data collection can be found in the draft Test Plan and Technical Protocol (see Sec. 5.9).

4. DEMOBILIZATION

Once all the necessary tests have been completed at the Wright-Patterson AFB site, all the equipment will be disassembled by the staff. The equipment will then be moved back to the holding facility where it will remain until it is determined what site it will be mobilized to next. Battelle staff will receive this information prior to leaving the site, and will be responsible for the shipment of the equipment to the next site.

<u>Bioslurper System Discharge</u>

1. VAPOR DISCHARGE DISPOSITION

Battelle expects that the operation of the bioslurper test system at the Wright-Patterson AFB site will require a waiver or a point source air release registration, and may require some additional permits. However, due to the short duration of the bioslurper pilot test and the 5-hp sized pump that will be used, it can be assumed that the concentration of hydrocarbons (approximately 8.1 mg TPH/L) released to the atmosphere will not exceed 19 lb/day. This discharge rate is an estimate based on existing field data from a bioventing study performed at Wright-Patterson AFB during the past year. This rate should remain relatively constant throughout the pilot test. The vapor stream generated by the bioslurper system likely can be discharged directly to the atmosphere because of the short duration of the test and the low concentration levels of TPH and benzene in the vapor stream. If direct discharge is not allowed, activated carbon treatment of the vapor discharge is an option.

To ensure the safety and compliability of the bioslurper system, vapor discharge samples will be collected periodically throughout the bioslurper pilot test. Also, field soil gas screening instruments will be used to monitor vapor discharge concentration variability. Furthermore, the volume of vapor discharge will be monitored daily using other field instruments. If state regulatory requirements will not permit this amount of discharge of the vapor stream to the atmosphere, please inform AFCEE and Battelle so that alternative plans can be made prior to mobilization to the site. Table 2 presents the information that is typically required to complete an air release registration form.

2. AQUEOUS INFLUENT/EFFLUENT DISPOSITION

The volume of groundwater pumped by the bioslurper will be less than 5 gpm. However, in Ohio it may be necessary to obtain a groundwater pumping waiver or registration permit. If one is required, the base PoC will inform Battelle of the necessary steps in obtaining the waiver or permit.

The operation of the bioslurper system also will generate an aqueous waste discharge. The intention of Battelle staff will be to dispose of the wastewater discharge directly to the base wastewater treatment facility. The wastewater discharge rate during the test period will be less than 5 gpm. If existing base wastewater channels can be used, no National Pollutant Discharge Elimination System (NPDES) or other water discharge permits will be required.

Table 2. Air Release Registration Data

Data Item	Air Release Information
Contractor point of contact	Jeff Kittel (614) 424-6122
Contractor address	Battelle 505 King Avenue Columbus, Ohio 43201-2693
Estimated total quantity of petroleum product to be recovered	TBD
Description of petroleum product to be recovered	JP-4 Jet Fuel
Planned date of test start	October 24, 1994
Test duration	5 days (active pumping)
Maximum expected VOC concentration in air	<20 lbs/day (18 lbs TPH/day, <2 lbs benzene/day)
Maximum total quantity of VOC release	<20 lbs/day
Expected contaminants in air release	TPH, Benzene (0.002 mg/L)
Expected quantity of fuel use (for electrical generator)	125 gallons
Type of fuel used	Gasoline and Diesel Fuel
Stack height above ground level	10 ft

3. FREE-PRODUCT RECOVERY DISPOSITION

The bioslurper system will recover free-phase product from the pilot tests performed at Wright-Patterson AFB. The free product that is recovered from the tests will be turned over to the base for disposal and/or recycling. The volume of free product recovered from the base will not be known until the tests have been performed. The maximum recovery rate for this system is 5 gpm. However, the actual recovery rates may be much less.

Schedule

The schedule for the bioslurper field work at Wright-Patterson AFB will be dependent on approval of the project test plans, and equipment availability during the week of October 17, 1994. Battelle will determine a definitive schedule as soon as possible. Battelle will have 2 to 3 staff members on site for approximately 2 weeks to conduct all the necessary pilot testing. At the conclusion of the field testing at Wright-Patterson AFB, all staff will return their base passes and will remove all field equipment from the base.

Base Support

The obligations of Battelle in the bioslurper initiative at Wright-Patterson AFB will be to supply all the necessary staff and equipment to perform all the tests on the bioslurper system. Also Battelle will provide technical support in the areas of water and vapor discharge permitting, digging permits, staff support during the extended testing period, and any other technical areas that need to be addressed. To conduct the necessary field tests at Wright-Patterson AFB, the base must be able to provide the following items:

1. Any and all digging permits and utility clearances that need to be obtained prior to the initiation of the field work. Any underground utilities should be clearly marked to reduce the chance of utility damage and/or personal injury during soil gas probe and well installation (if needed). Battelle will not begin field operations without these clearances and permits.

2. Access to the local sanitary sewer must be furnished, so that staff can discharge the bioslurper aqueous effluent directly to the base treatment facility. If the sanitary sewer is not available, Battelle and the Air Force will evaluate treatment options.

3. Regulatory approval, if any is required, will need to be obtained by the base PoC prior to startup of the bioslurper pilot test. As stated previously, it is possible that a waiver to allow air releases or a point source air release registration will be required. A waiver for pumping groundwater at a rate of 5 gpm might also be required. The base PoC will obtain all the necessary permits/approvals prior to mobilization to the site. Battelle will provide technical assistance in preparation of regulatory approval documents.

4. The base also will be responsible for the disposition of all waste generated from the pilot testing. This includes any soil cuttings generated from drilling, and all aqueous waste streams produced from the bioslurper tests. Also, all free product recovered from the bioslurper

operation will be disposed of or recycled by the base. Battelle will provide technical assistance in the disposition of the waste generated from the bioslurper pilot test.

5. The Air Force will be responsible for obtaining base and site clearance for the Battelle staff that will be working at the base. The base PoC will be furnished with all the pertinent personal information for each staff member.

The following is a listing of Battelle, AFCEE, and Wright-Patterson base staff that can be contacted in cases of emergency and/or required technical support during the bioslurper field initiative tests at Wright-Patterson AFB:

Battelle PoCs	-	Jeff Kittel Eric Drescher	[redacted]
AFCEE PoC	-	Patrick Haas	
Wright-Patterson AFB PoC	-	Joseph Duffy	

PII Redacted

If there are any questions or comments, please call me at the number listed above.

Sincerely,

Jeffrey A. Kittel
Program Manager
Environmental Restoration Department

JAK/aa

Attachments

Emergency Telephone Numbers

Ambulance:	911
Ambulance, Fairborn, Ohio:	879-2221
Base Emergency Room:	257-2968 (Base telephones dial last 5 digits)

Closest Off-Base Hospital

Hospital: Grandview Hospital, 405 Grand Avenue, Dayton)	226-3200
Emergency Room:	226-3210
Poison Control Center:	
Akron, Ohio	1-800-362-9922
Columbus, Ohio	1-800-682-7625

Wright-Patterson AFB

Police Department:	257-6516
Fire Department:	257-7033

Off-Base Police

Ohio State Highway Patrol:	890-1111

Utilities

Electric Utility: (Dayton Power & Light)	259-7878
Gas Utility: (Dayton Power & Light)	259-7878
Telephone:	(614) 223-9578

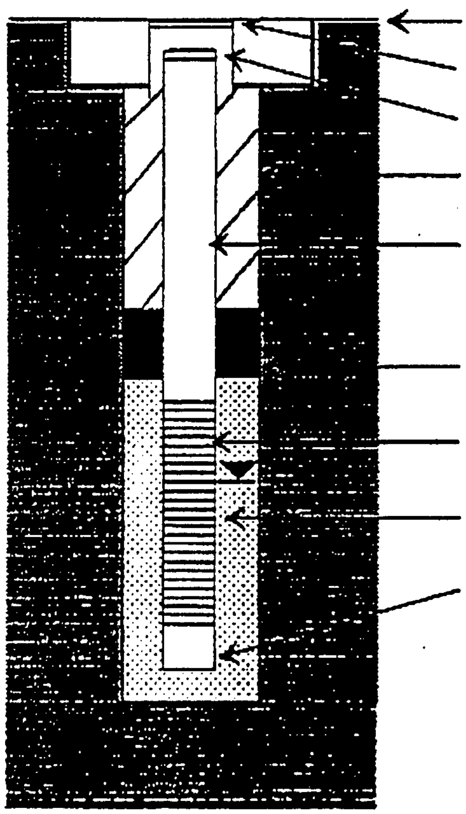
Emergency Route to USAF Medical Center

From OU-8, take Springfield Pike/State Highway 444 east to WPAFB Gate 9A. USAF Medical Center is visible to the left. Proceed through the gate along Estabrook Road. Turn left on Talbot Road and again turn left on Schlatter Drive. The USAF Medical Center is Building No. 830 and is to the left.

PIEZOMETER CONSTRUCTION SUMMARY

Piezometer No. :	P6-2	Drilling Company :	MOODY'S OF DAYTON
		Driller :	HERB WILLIAMS
		Drilling Started (Date) :	7/21/91
State Coordinates :		Drilling Completed (Date) :	7/23/91
Northings :	655242.53		
Eastings :	1551078.77	Well Completion Depth :	28.71
Reference Point :	TOP OF CASING		
Reference Point Elev.:	797.30	Development :	
Type of Security :	LOCKING CAP	Date :	8/05/91
		Type :	GAS PUMP
Supervisory Geologist :	WAYNE STONER	Volume Removed :	APPROX. 324 GALS.
Log Book/Page No. :	24/32-53		
		Post Devel. Water Level :	776.76
		Date :	8/05/91

PIEZOMETER AS-BUILT



		BLS	MSL
Land Surface:		0.00	797.51
Flush Mount Vault:		0.05	797.46
Top of Riser:		0.21	797.30
Cement/Bentonite Grout:	Top:	0.21	797.30
	Bottom:	11.25	786.26
Riser:	Top:	0.21	797.30
	Bottom:	17.77	779.74
Water Level:	▼	20.54	776.97
Seal:	Top:	11.25	786.26
	Bottom:	13.25	784.26
Screen:	Top:	17.77	779.74
	Bottom:	27.45	770.06
Sand Pack:	Top:	13.25	784.26
	Bottom:	28.71	768.80
Bottom Sump:	Top:	27.45	770.06
	Bottom:	28.45	768.80
Borehole Total Depth:		29.01	768.50

All measurements in feet unless otherwise noted
BLS – Below Land Surface
MSL – Mean Sea Level
NR – Not Recorded

NOT TO SCALE

CH2M HILL

PROJECT NUMBER	BORING NUMBER	SHEET	OF
SLE70380.FI.FS	048-SB6	1	1

SOIL BORING LOG

PROJECT OU8 RI/FS LOCATION W of C Street, Close to PG-2

ELEVATION ______ DRILLING CONTRACTOR Alliance Environmental

DRILLING METHOD AND EQUIPMENT Mobile B59, HSA 4 1/4", SS 2" w/140# Hammer

WATER LEVELS ______ START 8/1/94 9:16am FINISH 8/1/94 11:10am LOGGER J. Lamont

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	SS-1		1.2ft	5-15-27-17	Top Soil (Black Organic Rich) some gravel. Silty Sand (ML)	OVM Survey = 0 ppm; OVM Headspace = 0 ppm; OVM on Cuttings + TOA 0 ppm. S06SS801ON
	SS-2		1.4ft	5-15-6-7	Clay/Silt dark brown to Black in color. Slightly moist, some plasticity, slightly dense (ML) some fine sand	OVM Survey = 0 ppm; OVM Headspace = 0.9 ppm; Cuttings + TOA = 0 ppm. S06SS802ON
5	SS-3		1.1ft	5-4-4-5	Grades to a fine sand & silt trace gravel. Brown in color med. moist (Cemented) (SM)	OVM Survey = 0 ppm; Headspace = 0.9 ppm; Cutting + TOA = 0 ppm. S06SS803ON
	SS-4	Grain Size	1.4ft	11-13-10-16	Grading to a med sand & gravel w/some silt, gravel up to 3" in dia., subangular to well rounded (SP)	OVM Survey = 0 ppm (But thought I smelled hydrocarbons); No Headspace - Not enough; Cuttings + TOA = 0 ppm. S06SS804ON. Collected Grain size sample
10	SS-5		1.2ft	10-66-30-26	As above w/ just a bit of silty clay in tip of spoon (SP)	OVM Survey = 1.2 ppm; Headspace = 0.3 ppm; Cuttings TOA = 0 ppm. S06SS805ON
	SS-6		1.7ft	11-36-36-28	As above grading slightly to a med. to coarse sand & gravel (SP) slightly moist	OVM Survey = 0.6 ppm; Headspace = 0 ppm; Cuttings + TOA = 0 ppm but driller thought he smelled something. S06SS806ON
15	SS-7		1.6ft	6-20-16-16	As above (2" seam of silty clay @ tip of spoon) (SP)	OVM Survey = 0 ppm; Headspace = 0 ppm; Cutting + TOA = ~~30~~ 0 ppm. S06SS807ON
	SS-8		1.7ft	9-6-7-4	As above (SP) Tip of spoon w/ pretty moist.	OVM Survey = 0 ppm; Headspace = 0.7 ppm; Cutting + TOA = 0.1 ppm. S06SS808ON
20	SS-9		1.4ft	4-6-7-8	As above @ 21 ft Soils discolored black w/ fuel (prob) diesel)	OVM Survey ~ 128 ppm; Headspace = ~~[illegible]~~ ppm; Cutting + TOA = 0 ppm. Strong Hydrocarbon odor. S06SS809ON
					As above (SP)	OVM Survey (SP) = 8 ppm (Nothing on clay)
				3-7-10-16	Gray silty clay or clayey silt w/gravel (gravel up to 2" in diameter	Headspace; Cutting + TOA = 0 ppm. S06SS810ON
25					23.5 ft (EOH - End of Hole)	
						= samples sent for CSC analysis
30						

REV 11/89 FORM D1586

(8.30)

CH2M HILL

PROJECT NUMBER	BORING NUMBER	SHEET
GLE 70380.FI.FS	OU-8 SB-10	1 OF 4

SOIL BORING LOG

PROJECT OU 8 - RI/FS LOCATION W of C Street, E of Bldg 490, N of P...
ELEVATION DRILLING CONTRACTOR ALLIANCE ENVIRONMENTAL
DRILLING METHOD AND EQUIPMENT MOBILE B59, 4 1/4" AUGERS, 2" Split Spoon, 140 lb hammer
WATER LEVELS 8-4-94 07:53 21.59' ~~8-4-94 09:30 31.85~~ START 8-3-94 16:50 FINISH LOGGER K. KIMBLE

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0		Unable to pound spoon			ASPHALT & CONCRETE	
2	2.5					
	2.5–4.5	SS1	1.5'	3-6-8-10	CLAYEY SILT (ML), dk brown to black, dry to moist, firm, slightly plastic	S10DSB010N ~~16:50~~ 17:50; OVM Drill Cuttings/TOA - not measured; OVM Survey = 0 ppm; OVM Headspace = 0.8 ppm
	5.0–7.0	SS2	1.85'	2-4-4-4	CLAYEY SILT (ML), dk brown lightening to brown w/ depth, dry to moist, firm, slightly plastic, 1.7-1.85 Silty Sand (ML).	S10DSB020N 17:53; OVM Drill Cuttings/TOA = ~~0 ppm~~; OVM Survey = 0 ppm; OVM headspace = 0.4 ppm
6						
8	7.5–9.5	SS3	1.0'	6-11-13-12	Same as above, Clayey SILT (ML) 7.6 SILTY GRAVEL (GM-GW), lt. brown, some yellow, dry, loose, gravel up to 2" in diameter, well rounded.	S10DSB030N 18:00; OVM Drill Cuttings = 0 ppm; OVM Survey = 0 ppm; OVM headspace = 3.6 ppm
10	10–12	SS4	1.5'	27-21-21-19	SANDY GRAVEL (GM-GW), lt. brown, dry, with a moist zone at 1.3-1.4', dense, gravel up to 3" in diameter, well rounded. Gravel (65%) Sand (25%), Silt (10%)	S10DSB040N 18:12; OVM Drill Cuttings = 0 ppm; OVM Survey = 1.6 ppm; OVM headspace = 2.0 ppm
12						

REV 11/89 FORM D1586

(8.30)

CH2M HILL

PROJECT NUMBER	BORING NUMBER	SHEET
GLF 70380.FI.FS	OU-8 SB-10	2 OF 4

SOIL BORING LOG

PROJECT 008 - RI/FS LOCATION W of C Street, E. of Bldg 490, No[illegible]

ELEVATION DRILLING CONTRACTOR ALLIANCE ENVIRONMENTAL

DRILLING METHOD AND EQUIPMENT MOBILE B59, 4 1/4" Augers, 2" Split Spoon, 140lb hammer

WATER LEVELS 8-4-94 07:53 21.59' START 8-3-94 16:50 FINISH LOGGER K. Kimble

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
12	12.5					
14	12.5–14.5	SS5	1.2'	9-17-6-8	GRAVELLY SAND (SW), lt. brown to orange brown, dry w/ some moist zones, med. dense, gravel up to 2" in diameter, well-rounded	S10DSB050N 18:20 OVM drill cuttings = 0ppm OVM Survey = 0ppm OVM head space = 2.4ppm
	15					
16	15–17	SS6	1.4'	3-4-9-13 (16)	SAND (SP), lt. brown to orange brown, moist, loose, fine-grained, well sorted SANDY GRAVEL (GM-GW), lt. brown w/ yellow, dry, gravel up to 2" in diameter	S10DSB060N 18:26 OVM drill cuttings = 0ppm OVM survey = 0ppm OVM headspace = 2.4ppm
	17.5					
18	17.5–19.5	SS7	1.2'	4-8-6-8	GRAVELLY SAND (SW), lt. brown to orange-brown, dry, up to 1" in diameter, well rounded to sub-angular	S10DSB070N 18:40 OVM drill cuttings = not measured OVM survey = 0ppm OVM headspace = 2.4
	20					
20 20.4	20–22	SS8	1.6'	∇ 20.4 2-3-6-8 21.1	GRAVELLY SAND (SW), same as above Silty CLAY (CL) w/ sand and gravel, tan to orange-brown, dry to moist, plastic	S10DSB080N 18:47 OVM drill cuttings = not measured OVM survey = 81ppm OVM head space = 237ppm
22	22.5					S10DSB090N 18:54 OVM drill cuttings = 48ppm OVM survey = 0ppm OVM head space = 50.7ppm
24	22.5–24.5	SS9	1.6'	3-7-9-14	SILTY CLAY (CL) w/ sand and gravel, grey-brown, moist, plastic, gravel up to 1" in diameter	end of day 8-3-94

REV 11/89 FORM D1586

(8.30)

TOTAL P.10